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ABSTRACT

The skill needs of Australian high-technology start-up companies and the implications of those skill needs for vocational education and training (VET) were examined through a study of 14 start-ups' inherent abilities to access the VET system and on VET's relevance to their needs. The case studies documented a strong demand and role for VET in the establishment and development of small global high-tech companies. Training provided by the VET system was implicated in the following areas: technical skills in photonics and biomedical/diagnostic areas; electrical and mechanical engineering; production and manufacturing; project, financial, and team-based management; recruitment and human resources; quality assurance; sales and marketing; and occupational and environmental health and safety. The study companies appeared to be as fully engaged with Australia's VET system as possible within the limitations of existing conditions. Several mutually beneficial methods for increasing interaction between the study companies and VET were identified. Two such methods were including photonics in training packages and government subsidies for short course delivery to new workers in high technology based companies. None of the companies anticipated the need for apprentices or trainees and most saw a technical and further education diploma as the minimum qualification for entry to employment. (Thirty-nine tables/figures are included. Lists of the information sources and individuals interviewed are appended.) (MN)

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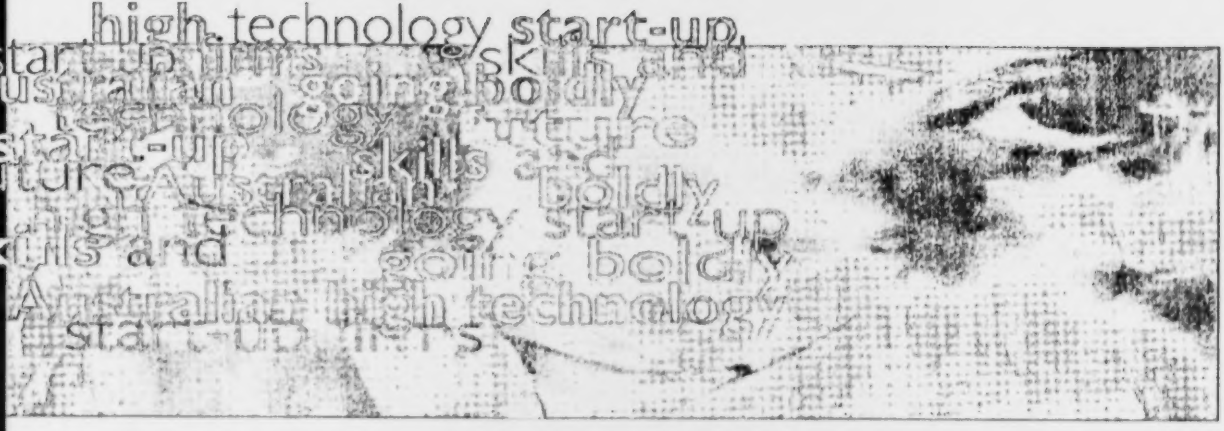

Going boldly into the future

Skills and Australian high technology start-up firms

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A companion volume based on the same study, ***Going boldly into the future: A VET journey into the national innovation system***, by Fran Ferrier, Clifford Trood and Karen Whittingham, is also available from the NCVER website, together with a volume of case studies used in the project.
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This study is only possible due to the culmination of the efforts of a large number of bold Australians who venture into new and exciting environments where unique knowledge, skills and jobs are created in emerging environments and industries.

The work was not possible without the assistance and vision of the chief executive officers and human resource teams of the companies mentioned in the study, nor possible without a special and unique environment which supported their emergence: the Australian Co-operative Research Centres program. Particular thanks to Elisabeth Elenius and Mark Sceats from Australian Photonics, Chris Howells, Karen Emmanuel and Tod Cambell from Redfern Photonics and Bruce Cornell from AMBRI.

It is not without some disappointment that we note the different economic climate operating at the time of publication to that at the time of the data collection. The reader will be well advised not to rely on any projected figures of employment in this study as the economic oulook in the telecommunications sector is somewhat poorer than it was late-2000 to mid-2001. Notwithstanding, the current outlook for the industry is still strong in the mid term. The forecast is still running at an average of 20% growth per year over a 10 year period.

I encourage the reader to stand with Professor Mark Sceats, chief executive officer of the Australian Photonics Co-operative Research Centre, and 'hold the faith when times are tough' and view the prospects of the Australian photonics industry and indeed all of Australia's emerging industries as sound. I commend this report to you and trust you enjoy sharing our journey.

Karen Whittingham
Director, TAFE Industry Partnership Centre, project manager

Preface

Photonic technologies are built from the underpinning knowledge and principles of light, lasers and electronics. Photonic technologies are developing in areas of telecommunications, diagnostic equipment and sensing devices.

In the telecommunications industry, photonic technologies will be the next generation in communication processes encompassing the entire communication food chain; fibre and its production and manufacture; the components and their production manufacture and application; the systems and their production; manufacture and installation and communication networks and their ultimate installation and maintenance.

The photonics industry can be cast into the following sub-markets:

- long haul cables
- application-specific fibres and cables
- active and passive components and modules
- systems and equipment
- metropolitan services

Photonic technologies can be used by the following industries:

- telecommunications
- medicine
- defence, military/aerospace
- consumer products
- laboratory products
- manufacturing

A biosensor is a 'compact analytical device incorporating a biological or biologically-derived sensing element either integrated within or intimately associated with a physicochemical transducer. The usual aim of a biosensor is to produce either discrete or continuous digital electronic signals which are proportional to a single analyte or a related group of analytes'. (Turner, A 1996, http://www.cranfield.ac.uk/biotech/chinap.htm)

This report is presented in a much broader context that examines the issues surrounding the ability to anticipate and predict skill needs in Australia's emerging industries and the mechanisms for response by vocational education and training (VET) systems. The full report is available upon request.

Executive summary

This study examines 14 new Australian high technology start-up companies in terms of their required skill needs. It examines the following questions:

- How many workers would be required to support the companies forming from the outputs of public sector research and development in this area?
- What are the types of training needed to ensure that the supply of skilled workers would be sufficient to meet the need of companies formed as an outcome of this research conducted in the co-operative research centre?
- What skills would be required?
- When would workers be needed?
- What level of training for workers would be required?
- Would workers need to be university qualified?
- What attitudes to training did new companies have?
- Could new companies articulate their needs?
- Do the people who start new companies know anything about VET?

The study also fundamentally seeks to assess the inherent ability of these companies to access the VET system or indeed have their needs met by the Australian vocational education and training system.

The study does not seek to assess the companies' management approaches, nor relies on any particular theoretical model of innovation or commercialisation, but rather seeks to describe these companies as and how they relate to the VET system at a particular moment in time. In that vein it is a preliminary look at innovation and skills where 'the light hits the tunnel' so to speak. It paves the way for more theoretical examinations but leaves open the possibility of national changes in policy for the VET system in terms of innovation and emerging industries.

The data show clearly a strong demand and role for VET in the establishment and development of small global high-tech companies. Training provided by the VET system is implicated in the following areas:

- technical skills in photonics and biomedical/diagnostic areas
- electrical and mechanical engineering
- production and manufacturing
- project, financial and team-based management
- recruitment and human resources
- quality assurance
- sales and marketing
- occupational, environmental health and safety.

The need and demand for VET qualifications is very strong.

Many of the companies reflected the culture of US-based operations and a number of companies in the study are no longer wholly owned in Australia.

In terms of management skills, interestingly, the mix of senior executives is strongly Australian, with most being drawn from leading Australians in the telecommunications industry and a significant number who also had start-up experience.

Management styles and skills changed significantly as the company moved from start-up to mass-manufacture. However the traditional management competencies of teamwork, project management, financial management, problem-solving skills, resources management, health and safety awareness and high communication skills were implicated for all workers in the company, not just those in management positions.

TAFE/VET qualified jobs created by the photonics companies by 2002 will number at least 283 and the number of university-qualified positions will be 575. Of these, 419 are postgraduate qualifications. The proportion of VET jobs in the cluster now is 16% but will rise to a minimum of 27% and is in fact likely to be higher by 2002.

Companies noted that the qualification demands were not necessarily for new workers. In fact many noted that they required graduates from both university and VET with experience. The preference of companies was not to recruit fresh from the universities or TAFE. Where this had occurred, in most cases, students were undergoing classes to obtain recognition via a qualification of their existing skills.

There are a number of ways these companies could interact with the VET system that would be beneficial to both organisations. By all accounts, the interviews indicated that these organisations are engaged as fully as they can be with the VET system, within the limitations of existing conditions. Further involvement would be assisted by the inclusion of photonics competencies in training packages and government subsidies for short course delivery to new workers in high-technology-based companies.

Not one company anticipates the need for apprentices or trainees in the short, medium or longer term and most see a TAFE/VET diploma as a minimum standard of qualification for entry to employment, with one company strongly indicating it requires a minimum standard of university graduate.

No organisations identified entry-level workers as having a place in the company, and many companies were quick to point out that the staff without Australian recognised qualifications had, in general, degree or VET-level qualifications from overseas institutions.

Current involvement in training activities is sporadic and is fundamentally dependent upon the stage of development of the company. Companies in the research and development phase or at very early stages of development are not inclined to view training as such a great priority as those about to commence manufacturing operations.

Most importantly, the degree of awareness of the VET system predetermined the way the companies described their needs. Those who understood the system would describe their needs being fulfilled by registered training organisations and the courses accredited under the training package system, while those who did not described their perceptions of the TAFE system, its courses and its colleges. All shared one thing in common: they fundamentally believed that the education system would provide the right people at the right time, but were hesitant as to how.

While demand for training may be high, the need is often poorly articulated and riddled with misconceptions about the training system, as the system is generally not well understood. Generally, we found that the attitudes of chief executives and human resource managers to training and

training providers were fairly positive, with all respondents keen to assist in the development of such training because they perceived it as advancing the industry in Australia.

Many factors affected a company's need and demand for training including: investment and growth; new processes and systems; new management approaches.

These companies had unique demands for skills, including the following:

- The need to take PhD and Masters 'virtuosos' (who were often found to be unemployable, because of their single-person project focus) and infuse team work, leadership and communication skills.
- Reliance on foreign investment and the links and ties to the established markets in photonics through investment, creating a possibility that manufacturing jobs will be located offshore. Training demand will suffer as a consequence.
- A perceived greater difficulty to find the time or resources to release staff for training activities that larger or more fully developed companies could afford to do.
- The high level of underpinning knowledge and skill required even at the manufacturing technician level.
- Training is not seen to be an enabler of business success in this (research and development and niche manufacture) phase of development of the company.

Many of the impediments to training in these companies were fairly traditional and can be found in the literature on investment in training. Reasons given for not investing in training can be explained as:

- within company factors
- external to company factors.

Within company factors were:

- state of development of the company (If manufacturing or development processes were not in place, a person's skill level could not be evaluated nor his/her training requirement.)
- perceived time constraints within production line deadlines
- high-level knowledge workers who could self-manage and learn on the job
- knowledge transferred outside the organisation
- perceived value to the company at its point in development
- cultural bias toward traditional VET providers.

External company factors were of greater interest in this study and included:

- a lack of available courses
- a lack of available trainers/instructors
- the cash cost of training and lack of government support
- a lack of a cohesive industry to support co-operation amongst companies on training issues
- significant structural weaknesses in the education system in identifying and anticipating needs
- a lack of knowledge transfer between the higher education and VET systems.

The study concludes that these technologies are in their incubation stage for a sufficiently long enough time for the VET system to be 'on notice' to provide skilled workers. Disruptive technologies, such as photonics, start with small student demand even when their economic impact is considerable. If one waits for large student demand to appear before developing the educational resources, one creates the likelihood, caused by the time lag between development and delivery, that

the demand will be met some other way, that is, by moving the technology development and manufacturing offshore to a country that already has the education resources or, indeed, has made the investment in the education system.

It makes the following recommendations:

VET agencies (including ANTA, state training authorities and state departments should improve the skills of VET planners in identifying emerging industry trends and determining rapid changes in technologies, to be better able to anticipate the need for training in early stage start-up companies and so be more vigilant in identifying these companies and the clusters they form.

VET agencies need to focus on providing training at Australian Qualifications Framework (AQF) 5 and 6 as entry-level workers are not required in the formative stages of high-technology industries. Trainees and apprentices are also not expected to have a place in the industry.

VET providers should provide trained workers who can articulate their needs, be aware of cultural differences, undertake problem solving and participate in teamwork; provide industry relevant (i.e. up to date with the latest technology and business processes) customised—just in time, on the shop floor—training to new firms that focus more strongly on providing training at AQF 5 and 6; create stronger links with research organisations and participate in applied research and development projects; establish partnership arrangements with researchers in industry and other educational institutions—to assist in the timely development and delivery of pre-emptive vocational education and training.

Industry training advisory bodies need to be better able to anticipate the need for training and therefore more vigilant in identifying new organisations and companies and clusters of these companies around new economic activity as they form and focus more strongly on articulating the need for providing training at AQF 5 and 6. This will support the development of training packages that incorporate the needs of new small to medium-sized industries who may not be sufficiently represented to articulate their needs to the appropriate bodies and have a mechanism for developing and incorporating competency standards from new and emerging industries in training packages in a timely and responsive manner.

The Australian National Training Authority needs to develop funding mechanisms for training for emerging industries and companies, particularly those that are a result of the publicly funded national innovation system. It also needs to develop mechanisms for the transfer of knowledge from the higher education sector to the VET sector, place greater emphasis on collaboration rather than competition between training institutes and states in 'new or thin' training markets and promote and support efforts of VET providers working with science and technology innovators where there is an undefined training market and expensive intellectual capital entry.

Future research could examine this topic in other industries to validate consistent issues so as to design a workable and systemic approach to the skill supply issues of Australia's emerging industries. It could study the diffusion models used by Australian research and development organisations for their effectiveness of knowledge flow into the VET system and a study on the effect of foreign investment into company development cultures and training choices would assist in assessing the training needs and demands of these types of companies.

In short, continual economic renewal is a feature of the new millennium. An investment at the beginning of the economic innovation funnel (i.e. research and development) without a corresponding investment at the end of the supply chain (i.e. skills and people) is like setting sail in a boat with no means of propulsion. The VET system must become more pre-emptive and anticipate the needs of these companies and new industries so that their skills needs and demands can be met when they hit the water.

Introduction

The objects of interest in this study are the holding and new companies (start-ups) established by the Australian Photonics Co-operative Research Centre and the Co-operative Research Centre for Molecular Engineering Technology. The Co-operative Research Centres program was designed and established in 1990 through the Commonwealth Department of Industry, Science and Resources to help realise the potential outcomes from public sector research. When the program was established, it was widely recognised that many publicly funded research outcomes were not taken up by Australian industry or by the wider community and that Australia's track record of establishing global high-technology companies was poor.

On 1 July 1992 the Australian Photonics Co-operative Research Centre and the Co-operative Research Centre for Molecular Engineering Technology were established as an unincorporated joint ventures between universities, enterprises and other government institutions. The centres have a board of governors who meet annually.

The Centre for Molecular Engineering Technology was funded for a period of seven years and included the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the University of Sydney and the Australian Membrane and Biotechnology Research Institute (AMBRI), which undertook the initial research on the ion channel biosensor. The research centre closed in 1999, and arrangements for the commercialisation of the intellectual property were made. These are described later in the report.

The Australian Photonics Co-operative Research Centre is still currently operating in 2003. In its first round of funding from the Commonwealth Government in 1992, the centre received A$28.48 million and also cash and in-kind contributions from industry. It was initially funded for seven years and established with five university and four industry participants. It was funded again by the Commonwealth as a co-operative research centre in 2000 for a further seven years receiving an additional A$27.4 million. The total resources for the centre in the new period including cash and in kind contributions is A$194.4 million. It now has 18 industry and five university participants with TAFE NSW, the Australian Electrical and Electronic Manufacturers Association and other organisations providing support.

The interest by TAFE NSW in the Australian Photonics Co-operative Research Centre is largely attributable to its early promise and the now perceived capacity to generate employment in a new global and high growth technology industry. The global photonics industry is currently valued at over US$50 billion[1]. Australia's current contribution to that is not known. The Australian Electrical and Electronic Manufacturers Association is undertaking a study to scope the Australian photonics industry. Such a study has not been conducted since 1997 and this was based on 1996 figures. At that time the Australian photonics industry was said to comprise 1.2% of the global market. If this was still the case, the current market value of the contributions of Australian firms to the global market would be in the vicinity US$600 million (A$1 billion).

[1] RKH International. www.rkh.com.au

Why photonics?

The needs of emerging industries and companies in the photonics industry prompted further study because of the collaborative efforts of the NSW TAFE Commission through its TAFE Industry Partnership Centre and the Australian Photonics Co-operative Research Centre at the Australian Technology Park, New South Wales.

In 1997, in collaboration with the centre, the TAFE Industry Partnership Centre had sought to assist the development of the photonics industry through investigating the need for training. The TAFE Industry Partnership Centre sought answers to the following questions:

- How many workers would be required to support the companies forming from the outputs of public sector research and development in this area?
- What training is needed to ensure a sufficient supply of skilled workers for the companies formed as a result of this research?
- What skills would be required?
- When would workers be needed?
- What level of training for workers would be required?
- Would workers need to be university qualified?
- What attitudes to training did new companies have?
- Could new companies articulate their needs?
- Do the people who start new companies know anything about vocational education and training (VET)?

Difficulties in answering these questions arose when it became clear that the industry was too 'young' to be able to articulate its needs or know the extent of its opportunities. At the time of engagement with the centre, there were only two start-up companies in the photonics centre stable: Virtual Photonics and INDX, both of which had fewer than ten employees and neither of which were close to full market commercialisation of their products. Few other companies outside the centre had been formed. Thus there was no coherent cluster of companies, no industry association nor other peak body. Simply all the centre and its joint venture partners could say with any certainty at the time, was that there would be the need for a vast number of workers and that many of those required would be in technical jobs and probably come from technical and further education (TAFE) colleges. Essentially there was a promise of a new industry but no guarantee of success.

One of the main reasons why researchers couldn't articulate their needs was that they were too early in the research, development, commercialisation cycle. A company with a product specification may not have a chief executive officer, and without investment or venture capital may also be lacking a realisable business plan. Because of this, the company has not determined its development, manufacturing or production systems and therefore does not have a human resource plan. Thus it does not know what type of workers it needs, the qualifications it wants or the essential skills its emerging culture requires.

Throughout the process of assisting the co-operative research centre in its engagement with the larger VET system, it became apparent that the VET system was geared for responding to industries who can articulate their needs through the 'regular' channels such as industry associations, forums etc. Without an industry training advisory board or association to lobby the system on its behalf, the industry would not be able to influence the development of the labour market in a way which would assist its growth. Despite its growth over the past four years, industry support mechanisms are still not sufficiently in place for this to occur.

The TAFE Industry Partnership Centre assists the co-operative research centre and its companies to negotiate the VET system. It has created links between the centre and the information technology industry training advisory boards, both state and national, and acts as an interpreter of the VET system for these companies. The Industry Partnership Centre and the co-operative research centre and its start-up companies conduct school tours and student visits of the company facilities. In this way, over 1500 NSW school students have been exposed to this new industry.

The purpose of this report is to illustrate the needs, capabilities and challenges of the new companies being formed from public sector research, development and commercialisation through the Co-operative Research Centre program, particularly in relation to vocational education and training. It is intended to provide a basic guide to the requirements of start-up companies in high growth industries and to point to areas where VET could be of assistance. Of particular interest in this study, the area of photonics is examined, but I believe that many other emerging industry sectors face the same challenges.

This report seeks to tackle the following questions of the larger study of which this is a sub-section:

- Do emerging technology companies have skill and qualification needs which are similar to those required in established industries or is there (or will there be) a requirement for a new type of knowledge/technician worker?
- What approaches to training are taken by emerging technology companies? For example, do they prefer to liaise with local colleges or training funding bodies, to train inhouse, or to recruit skilled labour outside the firm?
- What (if any) reasons/benefits do they identify for early investment in training?
- What (if any) impediments do they identify which inhibit investment in training?

The report did not specifically seek to examine questions or details pertaining to the detailed needs or demands for 'soft' skills, generic skills or embedded knowledge. However, the reader will find that companies have identified these areas/issues as significant items in their need and demand for training.

The profiles of the companies examined and limitations of the profiles

A literature review was conducted for the main project 'Predicting skill needs in emerging industries and mechanisms for response by VET systems'. It is important to note that it did not uncover any studies conducted within the Australian VET system that examined the impact of, or impediments to, training in or for high technology firms in global high growth or new industries. The closest paper was one by Richard Curtain (1997), entitled 'Transition problems in small high technology firms'. As a consequence, our work is the first of its kind in this country and thus we have sought to scope out and describe only a few areas of importance. A great deal more work is required in this area. We hope that this study begins an interest and provides future researchers with a base or context from which to proceed.

In each case study presented, we have sought to determine or describe the following:

- the business of the company (for accuracy purposes this has been directly lifted from the company's website or information belonging to them)
- corporate structures and management
- stage of development of the company, that is, research, development, early commercialisation, mass production
- existing staff qualification levels

- future staff qualifications profile
- type of worker characteristics
- forces impacting training decisions and investments
- training needs for the short and long term
- perceived impediments to training.

Where possible, these companies have provided the best information from their business plans and have made estimates based on the current value of the global market, its development, their place in it, and the receipt of venture capital to ensure their growth. In some instances, companies felt that some of the data that we were seeking would not serve them in the public domain and thus a few small sections have less data than anticipated.

It was intended, at the outset of this study, that we would interview a cross section of start-up companies which had spun out of a number of co-operative research centres (by 2000 the Australian Government had funded more than 67 of them), but we were unable to identify any centres who had formed clusters of companies or whose start-up companies were as advanced in their development as those from the Australian Photonics Co-operative Research Centre. With the data now collected, it is evident that the sample has identified a cross section of issues across the company industry development cycle which remain to be fully tested in a broader context. Naturally a larger pool of companies would have been preferable as it would have supplied us with a wider range set of insights and an opportunity to confirm the experiences of these organisations. This is now left to future researchers in this area.

I have therefore taken the decision to include in this report the case study profile of Ambri Ltd—the single start-up company from the Molecular Engineering and Technology Co-operative Research Centre—rather than profile it separately. Ambri is marketing a nanotechnology sensor into the medical diagnostic market. The similarities in experiences and problems described between the photonics companies and Ambri are too strong to ignore and indicate that we are indeed describing broader features of the Australian business, education and training landscape—not just those belonging to the photonics industry.

The profiles

A company-by-company profile is provided of *all* organisations generated by the Australian Photonics Co-operative Research Centre to date, as well as the profile of Ambri Ltd. It is important to mention that we chose to profile all start-up companies rather than those involved only in manufacturing. Thus we have included start-up companies that manufacture fibres and components, as well as those who support the development of such organisations. These include the Redfern Photonics marketing and licensing company as well as those responsible for the design of telecommunication systems. This feature is important to recognise for two reasons: firstly, because there appears to be some level of supply-chain integration occurring within the cluster; and secondly, the operational profiles and needs of the companies vary with their company profile and business plan.

Each profile has the following information:

- a description of the main activities of the company
- an overview of the company's development
- a statement about its corporate structure
- a description of the current staff and management including short management biographies
- a description of the current recruitment activities

- a section dealing with the company's VET sector involvement including:
  - a description of its current involvement
  - a statement about the forces it sees as impacting on training and training investment
  - its current training needs
  - its perceived impediments to training.

Interestingly each company described its workforce, its needs and its projections in different formats and styles. Even though much of the data can be compared, it is evident that each organisation becomes its own microcosm to be described.

Australian Photonics Co-operative Research Centre

All co-operative research centres are responsible under their agreement with the Commonwealth Government to have a 'well-structured, feasible and practicable strategy for the utilisation and commercialisation of the research'[1] it conducts. The Australian Photonics Co-operative Research Centre has arguably the most successful strategy of all centres to date. It has utilised a variety of the methods in place with other centres and has generated the greatest number of start-up companies.

The centre has successfully commercialised its research using the following strategies for utilisation/commercialisation:

- contract research and development
- sale of intellectual property
- licensing/technology packaging
- collaborative research
- transfer of co-operative research centres' researchers to industry/enterprises
- consultancies
- education and training
- patents and publications
- start-up company establishment.

The objects of study in this report can be described as the Australian-based/owned firms the centre holds intellectual property for, or in which it has some form of ownership or investment.

Like other co-operative research centres, the photonics centre has in the first instance formed one main company, Australian Photonics Pty Ltd. This is its main marketing and licensing company. The position of the remaining companies in this study can be described best by their relationship to Australian Photonics Pty Ltd.

Australian Photonics Pty Ltd (APPL)—company 1

Australian Photonics Pty Ltd is the technology marketing and licensing company of the Australian Photonics Co-operative Research Centre. The company is owned by the participants of the first centre. The company's board of directors is appointed by the centre's governing board. The company's premises are at the National Innovation Centre, Australian Technology Park, Eveleigh, NSW. Australian Photonics Pty Ltd has maintained a level of nine full-time management staff.

The company's major assets are the rights to exploit and sub-license the intellectual property developed by the centre and its participants. The company has intellectual property license agreements with the members of the centre, including the universities of Sydney and Melbourne,

[1] DISR 2000, Guidelines for applicants—2000 selection round and general principles for centre operations.

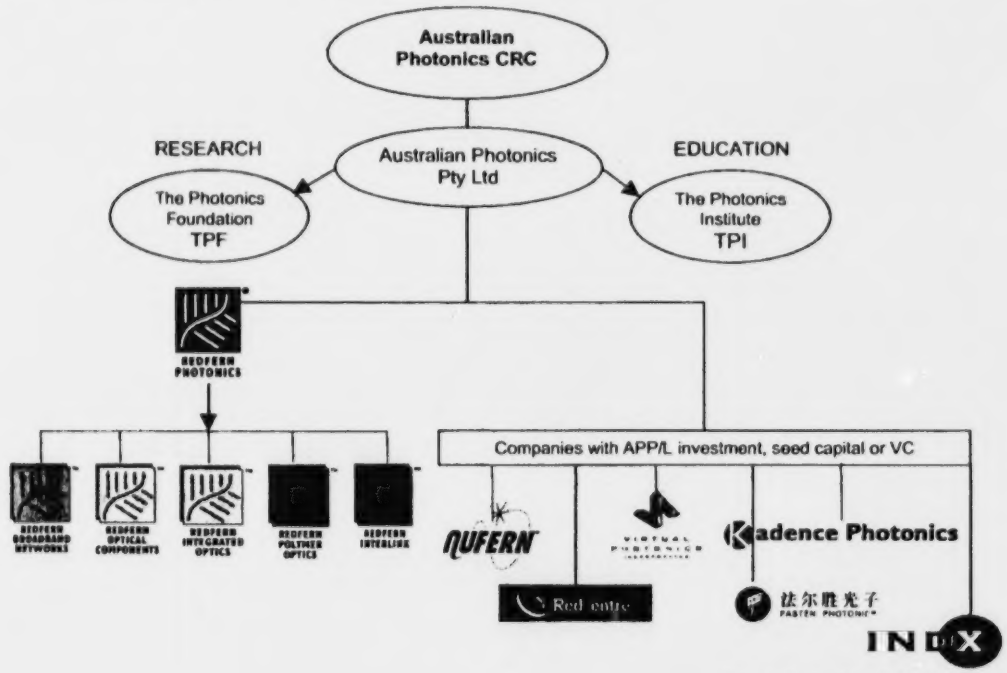
the Australian National University (ANU), and University of NSW (Unisearch), Telstra, and TransGrid (Electricity Transmission Authority). It is also progressing similar licences with the new research providers. The company sub-licenses this intellectual property to centre participants and other companies, receiving revenues in the form of sub-license, royalty and other fees, or taking equity in start-ups and joint ventures.

Corporate structure

The company structure is determined by its core intellectual property and patent protection activities. It has a chief executive officer, a legal team, and financial and administrative staff.

The commercial interests of the centre can be best described in the following diagram.

Figure 1: The Australian Photonics Co-operative Research Centre



Now wholly owned by JDS Uniphase

Australian Photonics Co-operative Research Centre: The AP CRC is described under the Commonwealth agreement for the purposes of conducting research and development, commercialisation and education in photonics.

Australian Photonics Pty Ltd: APP/L is the technology marketing and licensing company of the Australian Photonics Co-operative Research Centre.

The Photonics Foundation: TPF is a newly established division of APP/L to support long-term, high quality, scientific and technological research in photonics after the CRC funding from the Commonwealth ceases.

The Photonics Institute: TPI is a newly established division of Australian Photonics, which would provide a one-stop shop for the management of photonics educational material, services and marketing.

The Redfern Group of Companies: This is the commercial incubator company and its incubator/start-up companies for Australian Photonics Pty Ltd.

Redfern Broadband Networks (RBN) is manufacturer of broadband photonic networking products. The company delivers world-class, high-performance equipment that underpins communications systems.

Redfern Optical Components (ROC) was established in January, 1999 to manufacture and market optical components based on advanced grating devices, dense WDM filters with high band utilisation, high performance dispersion compensations and DFB fibre lasers.

Redfern Integrated Optics (RIO) specialises in the fabrication of silica-on-silicon-based planar waveguide structures and devices for a variety of research and commercial applications. The company employs a proprietary fabrication method that allows the integration of photonics and electronics into a single monolithic device.

Redfern Polymer Optics (RPO) specialises in the development of polymer-based planar lightwave circuits and integrated devices for advanced optical communication systems.

Redfern Interlink (RI) is in the early stages of being established and plans to install, commission and operate Gigabit Photonic Networks together with demonstrating photonic systems and equipment.

Nufern was initially established as Redfern Fibres Pty Ltd but its ownership has been sold. It is now Nufern International and its head office is in Connecticut, USA.

Redcentre is in the business of 'networking commercial opportunities' in photonics, opto-electronics, electronics and microtechnologies.

Kadence Photonics is developing a packaging and manufacturing capability for the Australian photonics industry.

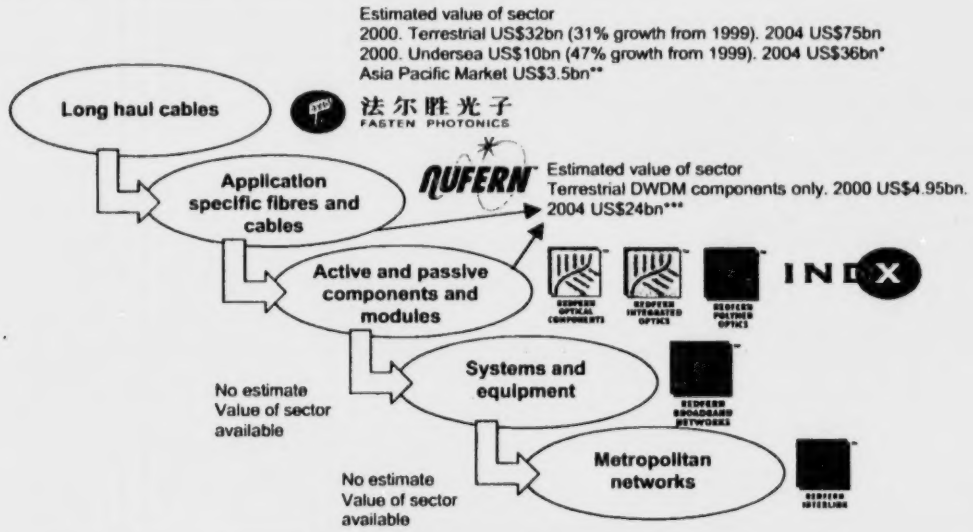
Virtual Photonics Incorporated (VPI) manufactures, and markets globally, photonic computer-aided design (CAD) software design tools.

INDX was sold outright by the CRC to JDS Uniphase in 1998 for approximately A$10 million. These funds have been used to bankroll the development of the other companies.

The Jiangsu Fasten Photonics joint venture is partially owned by the CRC and located in China. Its major products are Optical Fibre Preform, and Optical Fibre. About 60% of production will be for the Chinese domestic market and 40% for the overseas market.

Distribution of the centre's commercial interests across subsectors of the industry with current global market valuations is as follows:

Figure 2: Distribution of commercial interest of Australian Photonics CRC



* Cooperson, D 2001, RHK Incorporated, Optical Fibre Conference 2001 presentation.

** Walker, M, Vendors seek Asia Pacific rewards, RHK International, www.rhk.com

*** Lively, J 2001, RHK Incorporated, Optical Fibre Conference 2001 presentation.

**** RHK 2001, Analyst's report, March.

\# Terrell, G 2000, 'Photonics in telecommunications', *Photonics Spectra*, May 2000.

Current staff and management

Executive director, Professor Mark Sceats

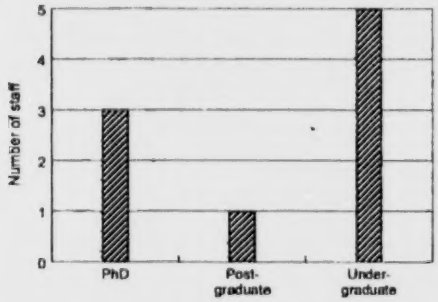
Professor Sceats received his BSc degree (1st Class Honours) and the University Medal in 1969, and a PhD in 1974 from the University of Queensland. He was a research associate at the James Franck Institute, University of Chicago, followed by an appointment in the Department of Chemistry and the Institute of Optics. He was awarded the prestigious Alfred P Sloan Foundation Fellowship for his work on solid state exciton dynamics. Professor Sceats returned to Australia in 1981 to work at the School of Chemistry, University of Sydney, and initiated activities that have led to the formation of the centres which he now leads. His role in establishing these activities was recognised through the award of Fellow of the Australian Academy of Technological Science and Engineering,

and Companion of the Institute of Engineers Australia. He was awarded the position of adjunct professor at the University of Sydney in 1998. In addition, he is a visiting fellow at the Australian National University and a Fellow of the Royal Australasian Chemical Institute. Professor Sceats is the chief executive officer of the co-operative research centre and also on the board of directors of the centre's start-up companies.

Other people in the company have the following roles:

- general management
- legal contracts/intellectual property portfolio, patents management
- communications
- finance and business
- administration.

Figure 3: Staff qualifications profile for Australian Photonics Pty Ltd



Australian Photonics Pty Ltd does not have any VET-qualified or entry-level staff.

Current recruitment

Australian Photonics is currently recruiting an office manager/receptionist. It is anticipated that this person will have a degree in communications or a TAFE diploma.

Projected qualifications profile 2001

There are no immediate plans to expand the company beyond the recruitment of an office manager.

VET sector involvement

Current involvement

Australian Photonics Pty Ltd has no current or formal connection with the VET system, apart from sharing staff with the co-operative research centre. A number of staff in Australian Photonics Pty Ltd have had long-term connections with the VET system and are familiar with its structures. Australian Photonics Pty Ltd staff have had contact with the Commonwealth Department of Education, Training and Youth Affairs, industry training advisory boards and TAFE NSW staff.

Forces impacting on training and training investment

The management company of the photonics centre oversees the longer term needs of the centre cluster companies. It identifies high rates of growth in the industry globally as the major force impacting on training needs and investment.

Training needs

The company identified the following training requirements:

- general computing skills such as Microsoft packages
- database and network management
- clerical and administration, general office procedures
- accounting.

It also noted that the technical training needs of the start-up cluster companies would have to be anticipated and met.

Impediments to training

Australian Photonics Pty Ltd identified structural weaknesses within the VET system as major impediments to training for its start-up companies. A lack of competencies in photonics in the telecommunications training package and a review period for the package of over three years that was 'already a lifetime in this industry' (national communications manager, APPL) were considered to be the most significant impediments.

The responsiveness of the NSW state VET system was considered to be adequate but national structures for co-operation between registered training organisations and development of training packages was considered to be 'unresponsive, unwieldy and dense' (national communications manager, APPL).

A lack of collaboration in the national interest was also perceived to be an impediment to training.

> The system does not appear to be set up to encourage collaboration between TAFE institutes or state systems. (National communications manager, APPL)

Poor inter-sectoral collaboration and communication was also seen to have an impact on training and the ability of the VET system to anticipate training needs.

> There appears to be a lack of collaboration and communication between TAFEs and universities, which makes it difficult for an emerging industry area to get the most benefit from its public sector expenditure. There needs to be a stronger linkage between public sector research and researchers and the VET system so that the VET system is aware of developments which could lead to new demands for technical training.
> (National communications manager, APPL)

The cost of training was also perceived to be too high for the start-up companies and thus was seen as an impediment to training investment.

Redfern Photonics Pty Ltd—company 2

Redfern Photonics Pty Ltd was established as the commercial incubator company for Australian Photonics Pty Ltd. This is the technology transfer company and manager of the intellectual property of the Australian Photonics Co-operative Research Centre.

Redfern Photonics' mission is to lead the photonics industry in the commercialisation, investment and global supply of high volume photonic components and systems that are renowned for their innovative technology, design and quality. Its vision is to develop innovative products with a strong focus on speed to market, competitive cost structures and customer service.

The company manages the early commercial development of the co-operative research centre's start-up companies. The functions it undertakes on behalf of the other Redfern companies include:

marketing, legal services, human resources management, investment and finances. In relation to skills, its human resources manager, Mr Glen Jelfs, acts as the human resources manager for all the Redfern start-up companies until they reach a size or stage in their development where it is feasible for them to recruit their own.

Corporate structure

Redfern Photonics was not established to manufacture or provide services to organisations, other than its subsidiary companies. It is only concerned with business issues such as capital raising, partnership and relationship arrangements, and marketing for the developing companies in its stable. Its corporate structure reflects a traditional management style with corporate growth as a major aim in the short term.

The company's development

The following table outlines the main developments in the company since its inception:

January 1999	Redfern conceived
June 1999	Venture capital received
January 2000	Chief executive officer appointed
January 2000	Chief technical officer appointed
January 2000	Chief operating officer appointed
May 2000	Staff from Australian Photonics P/L move into company
March 2000	Human resources manager appointed
May 2000	Marketing manager appointed
April 2000	Legal counsel appointed
Pending for May 2001	Further investment

Redfern Photonics Pty Ltd has established six companies to date. Several more start-up companies are planned in the near future. The business plans, corporate structures, staff numbers and qualifications profiles for those companies have not yet been determined.

Redfern Photonics subsidiary companies, staff numbers for 2001 and 2002

Company name	Number of staff at 1/4/01	Projected staff as at December 2002
Redfern Photonics	16	16
Redfern Fibres/Nufern	15	20
Redfern Optical Components	15	120
Redfern Integrated Optics	28	130
Redfern Broadband Networks	73	162 (for Dec 2001 only)
Redfern Polymer Optics	6	30
Redfern Interlink	1	1
Total number	**154**	**479**

As illustrated above, growth in staff numbers for the group over an 8–18 month period is 325. This is a 211% increase.

Current staff and management

Board

Currently, the board of Redfern Photonics comprises a number of people who hold positions of responsibility in Australian Photonics Pty Ltd, thereby ensuring the flow of both knowledge and capital to the Redfern company, and increasing its chance of success. The board structure is likely to change to take the company forward in the global marketplace.

Chief executive officer

Mr Christopher Howells is the chief executive officer of Redfern Photonics Pty Ltd. and brings to the group an extensive portfolio of operating experience in information and communications technology industries. He is the former chairman of Virtual Photonics Pty Ltd.

In 1982, after 15 years experience in the United Kingdom and Australian computer industry, Mr Howells founded NetComm Ltd which, as a private company, grew to A$30 million turnover before listing on the Australian Stock Exchange. He was the chairman and chief executive officer from 1982 to 1993 and then deputy chairman and chief executive officer until 1997. In 1996 he was appointed Chairman of Indx Pty Ltd.

Chief technical officer

The chief technical officer role is currently performed by Professor Sceats, the chief executive officer of Australian Photonics. His biography was given previously.

Chief operating officer

Dr Eric Heyde is the chief operating officer of Redfern Photonics Pty Ltd and offers the group a unique combination of both technical and financial business management acumen. Prior to this appointment, he held the position of general manager of Australian Photonics Pty Ltd, the parent company of Redfern Photonics Pty Ltd. In this role Dr Heyde was responsible for identifying and protecting key intellectual property, structuring businesses around intellectual property portfolios, and analysing the photonics industry and key opportunities within it. In addition, he was in charge of successfully seeking capital from the United States and Australian capital markets, and developing technology and business strategies for multiple companies in the photonics sector.

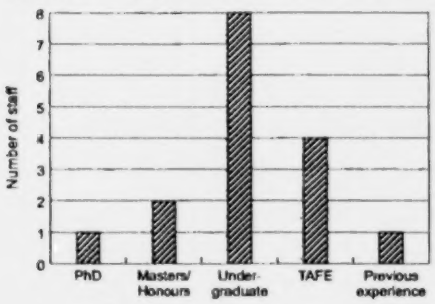
The remaining management team comprises:

- group general counsel/company secretary
- chief financial officer
- vice-president, business development and strategy
- senior vice-president, commercial
- senior vice-president, investments and funding
- group marketing manager
- business manager
- human resources manager

Remaining staff perform administrative roles.

Redfern Photonics Pty Ltd has 16 staff: three with postgraduate qualifications; eight with undergraduate qualifications; four with TAFE qualifications; and one with previous industry experience.

Figure 4: Staff qualifications profile for Redfern Photonics Pty Ltd



Additionally, a number of contractors are engaged on various projects at various times. These contractors are used to:

- ✧ assess the merits of proposed joint business ventures
- ✧ assess the nature of production facilities
- ✧ develop plans for manufacturing plants and other facilities.

Current recruitment

Redfern Photonics Pty Ltd are attempting to recruit two chief executive officers 'in waiting' plus a number of intellectual property managers for each of the subsidiary companies.

Staff projections and qualifications profile for 2001

There are no immediate plans to expand the company beyond its current level of service at this time. This may change due to business requirements.

VET sector involvement

Current involvement

Training issues identified by the company are directed towards the current training needs of the whole Redfern group. Current involvement with the VET system involves work being done to identify the company's needs with the NSW TAFE Commission, through Southern Sydney Institute. University involvement at this level does not occur.

Redfern Photonics assists in the placement of school and TAFE student work-based placements as well as conducting tours of company facilities and other demonstration events. In the past, these activities have been organised and facilitated by the TAFE Industry Partnership Centre at the Australian Technology Park, but increasingly specific requests are being made, often as a follow-up from previous visits.

The TAFE Industry Partnership Centre assists the co-operative research centre and its companies to negotiate with the VET system. It has created links between the research centre and the information technology industry training advisory boards, both state and national, and acts as an interpreter of the VET system for the Redfern group of companies. The Industry Partnership Centre and the co-operative research centre and its start-up companies conduct school tours and student visits of the facilities of the Redfern companies and over 1500 NSW school students have been exposed to the new technology industry in this way. TAFE students undertaking photonics modules tour the facilities regularly (at least once per term) and often the chief technical officers are available to discuss technical issues.

Direct recruitment from TAFE is beginning to occur, with students recruited from Mt Druitt and Lidcombe Colleges directly into this company.

Forces impacting on training and training investment

Transition of researchers to management is the greatest force impacting on training for this organisation. The perceived limitations of researchers transferring from technical roles to project management roles is significant. The human resources manager is concerned with the issues of *skills in communication and management.* It will use a combination of recruitment and inhouse training to improve the group company's performance in this area. The main human resources problem is finding/recruiting researchers who have sufficient experience *working in teams and undertaking or leading team-based projects.*

High rates of company and global growth have been identified as a factor influencing training need and demand. The start-up companies would need a significant number of workers across a range of disciplines if they were to be successful in meeting their business plan forecasts.

Training needs

The following immediate training opportunities were identified:

- environment, health and safety
- company and workplace induction
- team-based management
- financial management
- project management
- conflict resolution
- appreciating cultural diversity
- change management training
- induction training.

It was noted that *technical training* issues would be left to the human resources department of each specific start-up company to deal with, once it was large enough to need to recruit technical or implementation staff.

Impediments to training

The *phase of development* of the start-up companies is one main reason why the company does not consider a strong investment in training to be necessary at this time. Essentially the company is not sufficiently developed to require specific or generic training.

Cash to fund the costs of training is also considered to be a considerable burden, especially if the company is in its start-up stage and being 'bootstrapped' by the centre until venture capital is found to underwrite the development costs of the company. Training expenditure is low.

A lack of knowledge about the training system and easy access to training funds for start-up ventures has also been identified as a reason why training investment would be minimal.

Redfern Fibres—now Nufern International Inc—company 3

Redfern Fibres was established in February 1998. Redfern Fibres manufactures and markets specialty fibre, including:

- erbium doped optical fibres for amplifier and laser systems
- high NA silica fibres for fluoride and telluride fibre splices
- PF-1 pigtail fibre
- photosensitive optical fibre
- single mode fibre.

In March 2000, Redfern Fibres welcomed three co-investors, E-TEK, HRLD and Intel Capital. It is part-owned by the centre after selling a majority share to these investors. This new capital is planned for investment in extra research and development, new manufacturing and in securing relationships with new large customers in order to expand the adoption of centre technology.

The company name has changed to Nufern International Inc and its head office is in Connecticut, USA where a new manufacturing facility will be built to support the United States and European markets. Nufern International Inc makes leading technology specialty fibre for optic components for the DWDM telecommunications industry. These products are critical to making the next generation switches, amplifiers and routers required for the massive bandwidth used by the web-enabled industries and consumers. They also service some leading-edge aerospace and microprocessor-chip manufacturers with extremely specialised-edge fibres.

The following table outlines the main developments in the company since its inception:

February 1998	Redfern Fibres conceived
April 1998	Adrian Carter joins Redfern Fibres
August 1988	Justin Digweed, the second employee, joins Redfern Fibres
October 1999	Redfern's third employee, Andy Higley, joins
March 2000	Redfern Fibres attracts new investors
April 2000	Nufern International is born
May 2000	Australian employee-base doubles to six people
October 2000	Construction started on new facility in Connecticut (CT)
January 2001	Australian employee base-doubles again to 12
March 2001	Process equipment starts to arrive in CT
April 2001	Australian employee-base stands at 16 or 80% of expected total employee base of 20 people.
May 2001	Test equipment arrives in CT

Corporate structure

The corporate structure of Nufern reflects the investment by overseas venture capital and the decision to manufacture fibre products in the United States. Australian operations will specifically be for product development and only a small amount of special purpose fibre will be manufactured here.

Current staff and management

Chief executive officer

Martin Seifert was appointed in April 2000 as the chief executive officer based at the head offices in East Granby, Connecticut. He came to Nufern from the position of president and general manager of Lucent Specialty Fibre Technologies in Avon, Connecticut. Prior to his tenure at Lucent, he held

senior management positions with Schweitzer Engineering Laboratories in Pullman, Washington and Rockwell Automation in Milwaukee, Wisconsin.

Chief technical officer

Adrian Carter, the former general manager of Redfern Fibres Pty Ltd, was appointed to the position of chief technical officer for Nufern in April 2000. Prior to Redfern Fibres, he was a post-doctoral research associate and assistant professor at Brown University in Rhode Island. He was awarded his Doctor of Philosophy in the Department of Physical Chemistry, through the Optical Fibre Technology Centre, University of Sydney. He is the senior person at the Sydney laboratories that are set up to carry out research into new technologies and pilot line production.

The remaining management of the company in the United States comprises:

- general counsel
- vice-president, finance
- vice-president, marketing
- vice-president, operations

In Australia, the company comprises the following staff members:

General manager—Australia

David O'Connor was appointed general manager of the Australian facilities in September 2000 after spending the past ten years as a consultant building optical fibre and optical fibre cable facilities throughout Asia. Prior to the consultancy, he worked for Northern Telecom Canada Ltd, in various positions, leaving the position of divisional manager of Health, Safety and Environment.

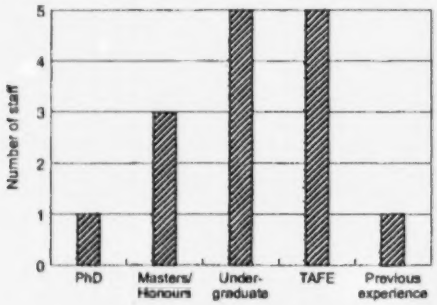
Quality manager—Australia

Ken Glessing, formerly the factory manager for a leading optical cable manufacturer in Asia—Leader Optic Fibre Cable S/B—and a former Northern Telecom Canada employee, joined Nufern in Australia in the capacity of quality manager. He supervised the implementation and maintenance of ISO 9001 and ISO 14001 for Leader Optic Fibre Cable, and brings this experience to Nufern to help ensure quality products for its customers.

Current staff qualifications profile

In Australia, 11 specialists with over 50 years of glass experience make up the workforce of glass fabricators, draw and test personnel. Their educational backgrounds vary from university and technical college graduates to trained skilled personnel from a secondary education stream. The remaining staff comprise management and administrative roles.

Figure 5: Staff qualifications profile for Nufern International Inc.



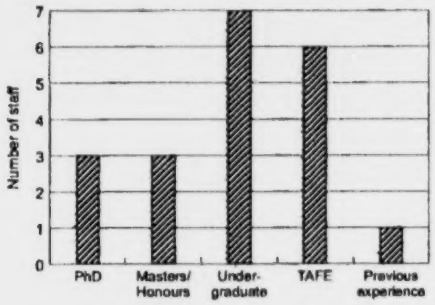
Staff projections and qualification profile for 2001

Currently, demand for fibre outstrips the supply ability of Nufern International Inc. Factories are planned in Australia and in the USA. The Australian operation will be primarily concerned with product development and the United States operation will manufacture specialist fibre. Australian operations are not expected to increase significantly (from 15 to only 20). The United States plant will be about 5000 m^2 and is expected to open in July 2001. It will house over 200 staff.

Currently Nufern International Inc is recruiting the following positions, all of which require a minimum university graduate qualification:

- director of advanced characterisation (US)
- polymer chemist (Australia)
- materials scientist (Australia)
- product manager (US)
- process engineer (US)
- sales application engineer (US)
- soldering/end prep engineer (US)
- test and measurement engineer (US).

Figure 6: Staff qualifications projections for the Australian operations of Nufern for mid-2002



VET sector involvement

Current involvement

Nufern is not involved in training through the VET system at this time.

Forces impacting on training

The training requirements of the company are affected by:

- overseas venture capital and the decision to manufacture there
- ability of the company to transfer its intellectual capital within and across its staff in house
- pre-existing determination of and record of excellence in manufacturing and production
- lack of 'scale' of operations in Australia—this refers to the small size of operations
- lack of opportunities for 'scoping up' of operations in Australia—new products developed and invented by the team in Australia will be transferred offshore for production.

Training needs

With regard to Australian operations, there will be no significant training need. New staff will be trained in the internal operations of the company on an inhouse basis. New plant and equipment is not expected to cause significant changes to production processes.

Impediments to training

A lack of need at this time and a small, highly-specialised operation were identified as impediments to training.

Redfern Optical Components—company 4

Redfern Optical Components Pty Ltd was established in January 1999, to manufacture and market optical components based on advanced grating devices, dense WDM filters with high band utilisation, high performance dispersion compensations and DFB fibre lasers. The company is negotiating with a number of potential investors.

These products have been released into the commercial market progressively from the last quarter of 2000.

In the latter part of 2000, substantial capital was allocated from the centre to the fit-out of 'clean' rooms and other production and office space at the Australian Technology Park to enable full production which commenced early in 2001.

The following table outlines the main developments in the company since its inception:

January 1999	Redfern Optical Components established
July 1999	Chief technical officer appointed
February 2000	Chief executive officer appointed
September 2000	Seed capital received
January 2000	Clean room and production facility established
April 2001	Staff numbers reach 16

Corporate structure

The corporate structure of Redfern Optical Components reflects the company as a small organisation based on a traditional management style with product development teams. The company is early in its development and will change significantly once it becomes ready for manufacturing operations.

Current staff and management

Chief executive officer (part-time)

Dr Allen Conduit, a co-founder of Fibernet, was appointed chief executive officer on 10 February 2000. Dr Conduit founded Fibernet Pty Ltd (Aust) in 1983 to market and manufacture fibre optic products which soon became the principal supplier to the regional telecommunications carriers, Telstra and Optus, and to Telecom NZ. Dr Conduit also has a successful background in joint venture companies. Whilst director of Fibernet Pty Ltd Australia, he initiated and established two major joint-venture companies with international partners in Japan and New Zealand in the area of fibre optics communications. In December 1996, Fibernet and its joint-venture companies were sold to AMP Inc, a US-based company with annual turnover of US$6 billion.

Chief technical officer

Dr Dmitrii Stepanov is the chief technical officer of Redfern Optical Components Pty Ltd. Dr Stepanov moved from a research position in the Optical Fibre Technology Centre, University of Sydney, to lead a team in the development of the company's product line. Prior to joining Redfern Optical Components, he was employed by the Australian Photonics Co-operative Research Centre where he was senior research fellow and worked on various aspects of fibre lasers, fibre laser sensors, fibre grating technology and its applications. In 1983, he joined the General Physics Institute of Russian Academy of Sciences where he conducted research in the areas of photo-induced phenomena in optical fibres and glasses, non-linear optics, and non-linear guided wave optics.

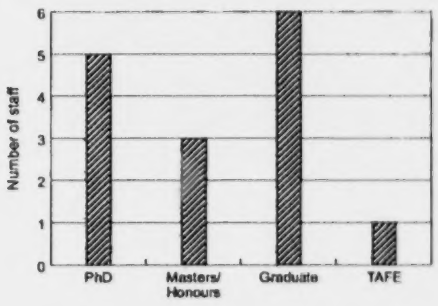
Redfern Optical Components also has the following staff:

- chief operating officer (acting)
- vice-president, manufacturing
- vice-president, engineering
- finance, marketing and human resources are handled by the parent company.

Current qualifications profile

At February 2001, Redfern Optical Components had 16 employees, all but one of whom had university qualifications.

Figure 7: Staff qualifications profile for Redfern Optical Components



Staff projections and recruitment profile for 2001

The Redfern Optical Components product is in the final stages of prototype development and the packaging of the product is being finalised. It is anticipated that customers will be able to purchase the product in the first quarter of 2002. The next phase of recruitment will be to recruit a full-time chief executive officer and chief operating officer at the vice-president and senior engineer level in operations and engineering. Redfern Optical Components is currently recruiting the following positions:

- photonics engineers (post-PhD with optical fibre device experience)
- quality assurance manager
- TAFE-qualified electrical technicians
- development engineers (with mechanical engineering background).

Upon completion of the product development phase, product development will scale down and manufacturing will scale up. It was anticipated that the company would recruit about 100 employees in the fourth quarter of 2001/ first quarter of 2002 in the following areas.

Operations: Production

This division of the company will require about 30 individuals who will be production engineers, machine operators and technical support. They will most likely be required to have a minimum of a TAFE qualification with five years industry experience, or a degree and some industry experience.

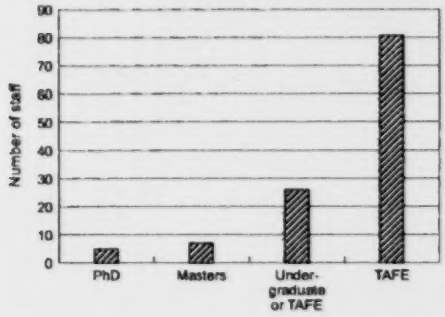
Logistics: Sales and purchasing, customer service

This division of the company will require about ten individuals who will undertake the sales and marketing as well as the administrative systems involved in customer service. These individuals will require a combination of TAFE or university qualifications and experience.

Manufacturing and production

This division of the company will require 60 individuals: 20 TAFE photonics technicians, 20 TAFE-trained manufacturing technicians where no photonics background is required, and 20 TAFE or university-trained electrical engineers.

Figure 8: Staff projections for 2002 for Redfern Optical Components



This company has a strong need for VET qualified staff.

VET sector involvement

Redfern Optical Components does not have a human resources manager of its own as yet. Its training needs are being met by the management of the parent company, Redfern Photonics Pty Ltd. All issues pertaining to training for this company can be found in the section on Redfern Photonics Pty Ltd. Currently the company is working with TAFE NSW to recruit an electrical engineering student.

Redfern Integrated Optics—company 5

Redfern Integrated Optics specialises in the fabrication of silica-on-silicon based planar waveguide structures and devices for a variety of research and commercial applications. The company employs a proprietary fabrication method that allows the integration of photonics and electronics into a single monolithic device.

Key advantages include:

- use of an intrinsically ultraviolet-photosensitive material allowing post-tuning of circuits
- use of proprietary techniques to eliminate birefringence
- the ability to integrate high-speed switches and modulators into silica-based photonic circuits.

Redfern Integrated Optics products include:

- thermo-optical switches
- variable attenuators
- high channel count arrayed waveguide multiplexers/demultiplexers for DWDM.

In March 2001, Advent International, Tallwood Venture Capital and TMT Ventures were welcomed into Redfern Integrated Optics as investors. The contribution was A$23.5 million. This investment accelerates plans for product development, marketing and the establishment of a United States office and new manufacturing facilities in Australia. The joint venture partners give international reach and strong technical credentials to the company and allow it to expand rapidly into the United States market.

The following table outlines the main developments in the company since its inception:

April 2000	Redfern Integrated Optics conceived
April – June 2000	Chief executive officer/chief technical officer appointed
August 2000	Chief operating officer appointed. Staff reach 14
January 2001	Human resources manager appointed
April 2001	Manufacturing management team appointed
March 2001	$23.5 million venture capital attracted
April 2001	Staff numbers reach 28
June 2001	Staff reach 53

Corporate structure

Redfern Integrated Optics currently utilises a traditional project-based management style. Staff are team-based and work across a number of concurrent projects. Most staff are involved in at least two projects and may support up to four projects at any one point in time. This structure suits the product development and prototyping phase that the company is currently undergoing.

The organisational structure will change upon commencement of manufacturing operations and as a consequence of recent investment from the investment and venture capital partners. The company will not decide on a management structure until such time as the manufacturing division is settled and production processes are well in place.

Current staff and management

Chief executive officer (part time)

Mr Bruce Board, a co-founder of Fibernet, was appointed chief executive officer of the company on 1 July 2000. His involvement in the telecommunications industry spans more than 26 years in the fibre optics/photonics sector. From 1985 to 1996, Mr Board was the joint owner, co-managing director and executive director for sales at Fibernet Pty Ltd. He is also the founder of Smartwaves Pty Ltd, a supplier of leading-edge photonic devices and support services to the Australian market which he initiated in 1999.

From 1974 to 1978, Mr Board was a member of Scientific Staff at Bell-Northern Research (now Nortel Labs) in Canada, responsible for design and development of optical fibre cables, connectors,

splices, splice closures. He was also responsible for field trialling of all new fibre optic outside-plant products within BNR, Bell Canada, Northern Telecom (now Nortel Networks).

Chief technical officer

Dr Michael Bazylenko was appointed chief technology officer in April 2000. He has 15 years experience in microfabrication research and development, process development and materials research and was senior research scientist with research and development laboratories of Scientific Industrial Corporation 'Integral', Minsk, USSR (1985–1992).

Dr Bazylenko was awarded the Ministry of Electronics Industry Award (USSR) for technology development of 1 MBit DRAM VLSI (1989). Working at the University of New South Wales, he presented the first demonstration of low temperature plasma deposition techniques for fabrication of silica-based planar photonic devices. He also led the University of NSW team to develop a complete planar waveguide manufacturing technology based on these techniques. He was the first to demonstrate low-loss silica-based waveguide technology compatible with optoelectronic integration (1995). Dr Bazylenko developed the concept and technological realisation of monolithic integration of active signal processing elements into silica waveguide. He has co-authored over 40 publications and holds 23 patents.

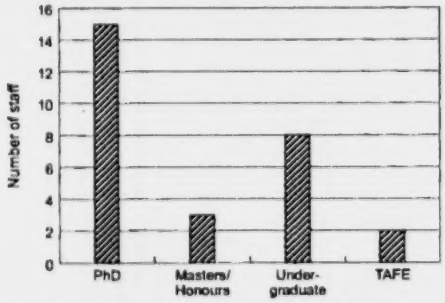
Along with the above-mentioned staff, Redfern Integrated Optics, has:

- vice-president, strategy and operations
- vice-president, engineering
- director, manufacturing
- human resources manager
- patent teams (intellectual property management).

Staff qualifications profile

Redfern Integrated Optics comprised 28 staff in February 2001. Several staff have advanced trade qualifications. These people have electrical, motor mechanical or toolmaking trade qualifications supplemented by industry experience.

Figure 9: Staff qualifications profile for Redfern Integrated Optics



Current recruitment

Redfern Integrated Optics is currently recruiting:

- vice-president, engineering
- process engineers
- research and development scientists

- ✧ manufacturing engineers
- ✧ facilities support staff
- ✧ quality managers
- ✧ test and assembly staff.

These positions require either degree qualifications or advanced trade qualifications.

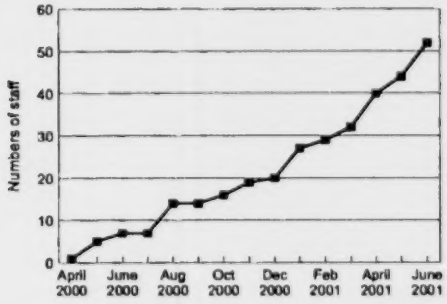
> All staff are expected to be self-starters who don't need to be told what to do. They need to be able to tell us what they need (plant and equipment, skills and staff) to be able to do their job.
>
> *(Human resources director, Redfern Integrated Optics)*

Redfern Integrated Optics' recruitment will enhance its product-manufacturing capability and is progressive. As can be seen from the following table, the staff numbers grew significantly at each major milestone.

The appointment of the chief operating officer was critical to the company's development. Once a basic management plan was in place, the management team was recruited and doubled staff numbers to 14 (research and development team).

The appointment of the human resources director increased staff numbers to 28 (product development and engineering teams) by 1 April. The injection of investment capital led to the recruitment of production and test and assembly staff. Staff numbers were expected to double again to 53 by 1 June 2001 (manufacturing team).

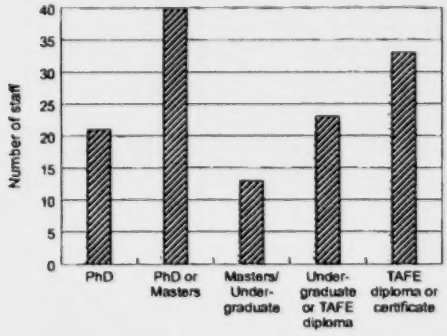
Figure 10: Staff growth for Redfern Integrated Optics 2000–2001



Staff projections and qualifications profile for 2002

Redfern Integrated Optics expects to have a minimum of 130 staff by mid to late 2002. The qualifications profile will approximate the following.

Figure 11: Staff qualifications profile for Redfern Integrated Optics



The main areas of recruitment will be for equipment operators (TAFE) and research engineers (university). Sales staff could be taken from TAFE or university but customer expectations for degree qualifications in the United States will drive recruitment in this area. Redfern Integrated Optics does not have any interest in entry-level employees. Their minimum qualifications requirement will be a VET/TAFE diploma or certificate qualification but is most likely to be a post-trade or higher level Australian Qualifications Framework qualification with some industry experience.

> We call post trade with experience, entry-level. When we reach the stage where we have grown enough to drill down production a few levels it may be possible that entry-level employees will be recruited but this is doubtful. The machinery is too dangerous and the contextual knowledge needed to operate it is too sophisticated to learn on the job.
>
> Many of our existing VET qualified staff have pre-existing overseas degrees or diplomas, that may not be recognised here. (Human resources director, Redfern Integrated Optics)

VET sector involvement

Current involvement

Redfern Integrated Optics leads the VET sector involvement within the Redfern Group as its human resources manager is well-versed in the National Training Framework, Australian Qualifications Framework, industry training advisory boards and other major structures of the VET system. He has previously been the business development manager of a group training company.

The current relationship with the VET system is focussed on the identified need for customised training delivery for frontline management. The company is currently negotiating with TAFE and private providers on costing and availability. The company also accepts TAFE students for work placement/experience and will be assisting in the review of the national telecommunications training package.

Forces impacting on training in Redfern Integrated Optics

The influence of United States venture capital has a significant effect on the start-up venture according to the company. The ability to adopt American work cultures and ethics, as well as risk-taking exercises in the company is essential. The venture capital partners look for these qualities when making investments and decisions about where to locate manufacturing operations.

The ***main changes to the company*** from this point will be the establishment of its manufacturing capability. According to the human resources director, the main challenge facing the company is to make its work processes simple.

> In a start-up company, enough things are confusing for workers, as many of the traditional processes are not in place, for example, petty cash or travel reimbursement. Processes need to be established and implemented quickly and the more transparent we can make it, the better it is for all staff.

For this reason, it is unlikely that through the next phase of development the company will adopt a more complex management style.

According to the human resources director, because of ***the way manufacturing operations will be conducted***, technical staff, apprentices and process workers need to ***know how the 'science' of photonics is being used in their specific job/task***. This enables improvement both in the company's processes and their product. It allows for continuous change. This view is in keeping with ideas expressed in the industry literature (*Optics and Photonics News* 1998).

The ability for process workers to *'manage up' and self-direct work* and be able to:

- declare where there is a problem
- what that problem is
- how much the problem is costing the company
- how much it will cost to fix the problem
- make requests from management for funding of solutions.

is imperative in a project-based structure. This communication is essential so that teams can do rapid change and skill transfer between teams.

Innovation management by all levels of workers is required in start-up companies. Risk management and the culture of trying something new is vital. Australians seem to lack the confidence to 'try something new' in terms of process improvements, and the United States success philosophy is lacking in Australian firms and culture.

> In order for *continuous change* to be successful, staff must have significantly better interpersonal skills. Change management is an essential skill and managing the emotional demands of this is the difference between an ordinary worker and one which will fit into a start-up company.

Recruitment practices in Redfern Integrated Optics place additional requirements on training. The company will take a potential employee who has superior interpersonal skills rather than one who has superior technical skills and inferior interpersonal skills ('even at AQF level 2'). According to the human resources director, assumptions by senior management that university graduates have better problem-solving skills tend to be substantiated in the workplace. In his view, the Australian Qualifications Framework and the training package structure do not lend themselves to teaching or integrating interpersonal skills well with technical knowledge.

> We can transfer skills and knowledge about our processes within the company and we can obtain skills by recruitment. What we can't buy is people who have excellent personal management and a success philosophy.

A number of personality characteristics and skills of employees were identified as being essential to the future success of the company.

Cross-skilling staff is an issue as the company has recruited a number of advanced post-trade members of staff.

> We have a motor mechanic, an electrician and a toolmaker. These are great skills for our company. We have found these people to be of high quality and will tend to recruit more in the future. They will however, need to understand more about how light works and more about the industry in which we are operating.

'Emotional labour' is seen as a valuable contribution by staff. According to human resources, staff with a high emotional quotient as well as intellectual quotient are important. The need for managers to recognise people (staff) who work long hours during the critical phases and provide rewards such as training and leadership responsibilities is also essential.

Cultural issues are being faced by this Redfern start-up company. For instance, some of the main holders of the intellectual capital 'know how' are of Russian origin. A number of additional staff has also been recruited from Russia because of their particular technical expertise, and thus the main language on 'the floor' is Russian. However, there are a number of other workers from Asian countries and several English workers. Conflict resolution in this situation caused the company difficulties, because different methods had to be used that were in keeping with the various cultures involved.

Training needs

Redfern Integrated Optics has stated that it has the following training requirements:

Immediate needs

- workplace health and safety induction training. The delivery would be on site and combined with classroom and flexible assessment. The company would like to meet the trainer to discuss structure, delivery, and customising content. The participant numbers would most likely be 12 but could be greater if co-ordinated with the other companies in the Redfern stable
- frontline management training—AQF 3 & 4
- Certificate IV workplace trainer.

> We need staff who can transfer their knowledge and specific skills to the people in their developing teams. (Human resources director, Redfern Integrated Optics)

Medium-term needs (8–12 weeks from 'ramp-up' to manufacture)

- strategy for funding of training to support manufacturing facility
- identify technical skills required in fabrication facility
- briefing on existing worker trainees
- strategy for assessment of existing technical staff against competency standards.

> We need workplace trainers and assessors who can be utilised to transfer skills within the company as it grows, and as the skill levels of each task/section area become more specific. This will also allow us to take a seed skill and multi-skill our teams.
> (Human resources director, Redfern Integrated Optics)

Longer-term needs (6–12 months from manufacture commencement)

- information technology skills training (MOUS certification [www.mous.net] Word, Excel, Outlook)
- enabling skills training (communications, conflict resolution, change management)
- visits to advanced manufacturing technology centres.

> Our processes are still being developed and our staff are still being recruited, so it is difficult to determine what training will be required in the longer term.
> (Human resources director, Redfern Integrated Optics)

Impediments to training

Redfern Integrated Optics identified a number of impediments to training. Its early stage of development was seen as an impediment. Not having production processes in place beyond those for developing niche prototypes was a problem.

> When we drill down production processes to specific details we may be able to determine the difference between the skills of the people we can recruit from the marketplace and what is required to do the job. Only then will we know what training we require.(Human resources director, Redfern Integrated Optics)

Similarly because the company was new, training was perceived as unnecessary at this time. It was not seen as vital to success in the start-up phase, whereas having high levels of graduate and postgraduate skills was seen as a crucial factor. In fact, training would even be considered a luxury for this company's next stage of development.

> Sustainable processes are not a priority at this phase of development, successful demonstration of the product capability is, we need to get products out the door in the first instance". Right now our headlights are only 3 months into the future. Training will be nice to have once we are up and running. (Human resources director, Redfern Integrated Optics)

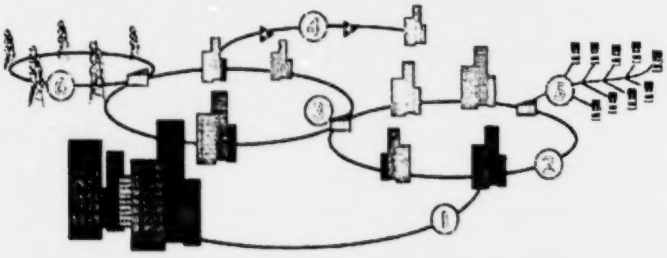
A lack of understanding of how other start-up companies deal with similar issues in manufacturing training and a lack of information about these processes in the marketplace was a similar issue. Not being able to see best practice in other firms was an impediment to training.

The cost of training problem was a significant issue for the company. The cost of training, even with government subsidies, was seen to be unaffordable.

Redfern Broadband Networks—company 6

Redfern Broadband Networks is an Australian manufacturer of broadband photonic networking products. Redfern Broadband Networks was established in October 1998. The company has emerged from its research and development incubation to deliver world-class, high-performance equipment that underpins communications systems. The company's flagship development, the Redfern Broadband Networks GigaWave™ Photonic Wavelength Management System, provides the foundation for the company's photonic networking equipment. This equipment includes optical terminal multiplexers, optical add/drop multiplexers, optical switching multiplexers and optical cross-connect products.

Figure 12: Application of Redfern Broadband Networks Technology



1 Shorthaul (<100km) point to point links
2 Metro ring networks
3 Multi-ring interconnected networks
4 Long-haul amplified links
5 Fibre to the curb/home
6 RF wireless feeder loops

In November 2000, the company received its first external investment funding from a consortium of the US-based Optical Capital Group, Chase H&Q and other United States investors totalling US$21.5 million; and US$6.5 million from Australian investors Allen & Buckeridge, Macquarie Technology Funds and the management of the Redfern Broadband Networks company.

Corporate structure

Redfern Broadband Networks utilises a mass production model for management. Its management matrix is complex and reflects ownership in the company by US-based firms. It has defined business areas within the company and is growing rapidly both here in Australia and in the United States.

The company's development

Redfern Broadband Networks is possibly the most developed company in the Redfern group to date. The following table outlines the main developments in the company since its inception:

October 1998	Redfern Broadband Networks inception by Australian Photonics P/L
November 98 – March 99	Business plan development
Feb 99	Registered as Pty Ltd company
March 99	Seed funding from Australian Photonics P/L
April/May 99	Two founders employed by Redfern Broadband Networks
June 99	Funding from Redfern Photonics
July 99 – February 2000	Prototype development
January 2000	Employees increase to 5
March 2000	Redfern Broadband Networks gigawave launched at OFTC conference Baltimore
Sept 2000	Redfern Broadband Networks Inc formed in Delaware Inc
October 2000	US$28 million funding
November 2000	The company grows to 40 staff and hires human resources consultant
February 2001	The company appoints human resources manager
February 2001	The company grows to 78 staff

Current staff and management

The management team of Redfern Broadband Networks is comprised of three key executives. Peter Davies, chief executive officer, leads the management team. Dr Richard Lauder, chief technology officer and Ross Halgren, chief engineer, are the co-founders of the company, and spearheaded the development of Redfern Broadband Networks GigaWave,™ including its commercial applications.

Chief executive officer

Prior to joining the company, Peter Davies was managing director and chief executive of JNA Telecommunications, an Australian telecommunications and networking company purchased by Lucent Technologies.

Chief technical officer

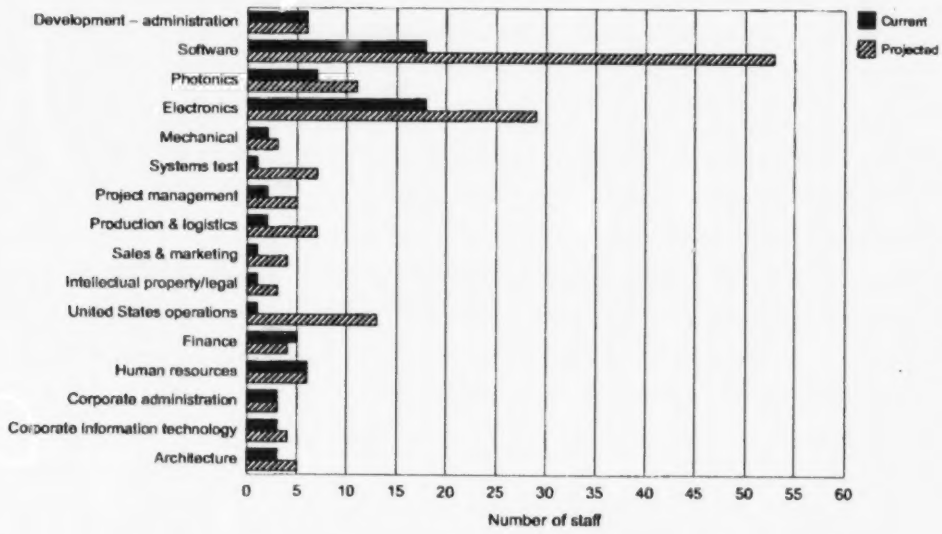
Dr Richard Lauder leads the technology development for the Redfern Broadband Networks GigaWave™ platform. He worked for three years as a research fellow at the Photonics Research Laboratory, and was also at the University of Southampton and British Telecom Laboratories in the United Kingdom.

Chief engineer

Dr Ross Halgren leads the company's experienced engineering team. He has more than 20 years experience in the fibre optics industry and has held key roles at Amalgamated Wireless Australasia including manager and technical director of local area network products, technology manager of networks and manager of the research laboratory at Amalgamated Wireless Australasia. In this later role, he was director on behalf of Amalgamated Wireless Australasia for Optical Waveguides Australia and attended board meetings at Corning's corporate office in Corning, USA. Ross was closely involved with the development of FDDI standards.

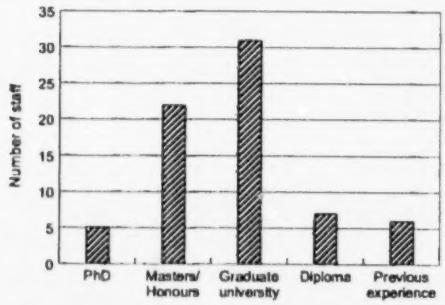
The company's staff provide a core competency across the areas of photonics, electronics and software design for optical networking products and have experience developing products for a variety of multi-national telecommunications systems companies.

Figure 13: Current and projected staff profile for 2001 across business areas within Redfern Broadband Networks



The composition of the company at February 2001 shows the 73 staff with the following qualifications profile.

Figure 14: Staff qualifications profile for Redfern Broadband Networks for 2001



Current recruitment

Current recruitment is targetted in the following areas:

- *Test engineers* (forecast to recruit five positions by December 2001)
  The essential qualification for these positions is a degree in engineering or related discipline (and/or) 1–5 years experience.
- *Software engineers* (forecast to recruit 41 positions by December 2001)
  The essential qualification for these positions is an excellent degree in computer science or computer systems engineering (or) exceptional degree in any discipline with appropriate graduate diploma in software engineering (or) no degree and exceptional experience in software development.
- *Photonics engineers* (forecast to recruit three positions by December 2001)
  The essential qualification for these positions is an MSc/PhD in electrical engineering or physics,

with at least five years design and development experience in the telecommunications industry preferred.

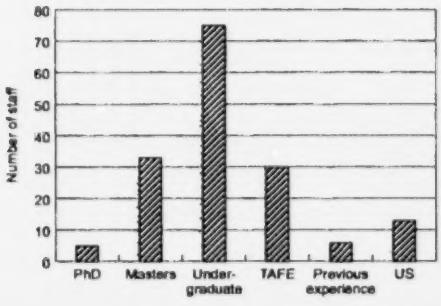
- *Electronic engineers*
  The essential qualification for these positions is an excellent degree in electronic or computer systems engineering.
- *Systems engineers* (forecast to recruit five positions by December 2001)
  The essential qualification for these positions is an excellent degree in electronic or computer systems engineering, with at least five years design and development experience, preferably in the telecommunications industry.
- *Senior project managers* (forecast to recruit four positions by December 2001)
  The essential qualification for these positions is an excellent degree in electrical, electronic or computer engineering, with at least five years design and development experience and three years project management experience.

The company's recruitment strategy includes internet advertising, the use of recruitment consultants, newspapers and billboard advertising.

Staff projections and qualifications profile for 2001

Labour projections for the remainder of 2001 had staff numbering 162 by 31 December 2001. (Previous projections made for 2001 were on target.)

Figure 15: Staff qualifications projections for Redfern Broadband Networks in 2002



VET sector involvement

Current involvement

Currently members of the company's staff are enrolled at Mt Druitt College of TAFE and are undertaking the Diploma of Telecommunications Engineering. In collaboration with the other Redfern companies, Redfern Broadband Networks is negotiating with TAFE NSW to undertake a variety of training in occupational health and safety, induction and frontline management.

Forces impacting on training in Redfern Broadband Networks

If company growth forecasts are correct, then the number of TAFE-related staff will increase from four up to about 30. Most of these will be in the software development areas.

Training needs

Currently, members of company staff are enrolled at Mt Druitt College of TAFE and undertaking the Diploma of Telecommunications Engineering and investigations in relation to frontline management training are occurring. Occupational health and safety and induction training are being conducted for the company by TAFE NSW.

Impediments to training

There is a strong bias toward academic qualifications within the company and this limits the entry of diploma-level candidates. It also limits the uptake of frontline management training and the possibilities for the delivery of other TAFE short courses to its staff.

Cash costs of customised training and time constraints for activities other than production were also identified as impediments to the implementation of training.

Redfern Polymer Optics—company 7

Redfern Polymer Optics specialises in the development of polymer-based planar lightwave circuits and integrated devices for advanced optical communication systems.

Redfern Polymer Optics has a unique materials system that enables the mass manufacture of planar waveguides with high optical performance and superior physical integrity using a low temperature, low cost process. The company's proprietary waveguide production method also enables rapid redesign and the ability to customise all devices. It is currently in development phase, targetting switching and modulating network applications, and expects to have its first products for sale in early 2003.

The current phase of development in the company is marked by significant secrecy and protection of its intellectual property.

The following table outlines the main developments in the company since its inception:

October 2000	Company established
December 2000	Chief operating officer appointed
April 2001	5 year plan in place
April 2001	Product specification finalised
May 2001	Research and development contract signed with Australian Photonics P/L

Corporate structure

Redfern Polymer Optics has a loose organisational structure but has decided early that it will not house a chief technology officer. It has employed a chief operating officer and specific project staff as well as other contractors who complete specific pieces of work for the company.

The company is at a very early phase in its development and only has a full-time staff of six with another nine contractors on specific projects.

Current staff and management

Chief executive officer

Ian Maxwell is the chief executive officer of Redfern Polymer Optics Pty Ltd and also vice-president, business development and intellectual property, of Redfern Photonics Pty Ltd. His role encompasses identification of new opportunities, co-ordination and management of new and existing operating subsidiaries and divisions of the company.

Prior to joining Redfern Photonics, he was research and development manager for the international building materials corporation, James Hardie Industries, responsible for new product innovation, technology planning, all corporate intellectual property and all functional areas in its various research and development groups.

From 1994 to 1997, he worked for Memtec Ltd (now part of US Filter). Memtec was a medium-sized global corporation focussed on the separation industries with manufacturing and research and development facilities throughout the world. During this time, he held the position of international research and development manager (1997), project member—glucose sensor (1996), membrane production plant manager (1995) and chief chemist (1994). He has also held research, lecturer and consultant positions in various universities.

Prior to that he set up the Sydney University Polymer Centre (now Key Centre for Polymer Colloids), ran his own company, Maxwell Chemtek Pty Ltd, and was a senior lecturer in Polymer Technology at the Eindhoven University of Technology in the Netherlands.

He has a PhD and BSc (Hons, 1st Class) degree from the School of Chemistry, University of Sydney in Physical Polymer Chemistry, and is also the recipient of the Rennie Medal of the Royal Australian Chemical Society. He has written ten book chapters, over 35 papers, and has more than 15 patents in various fields of science and technology.

Chief operating officer

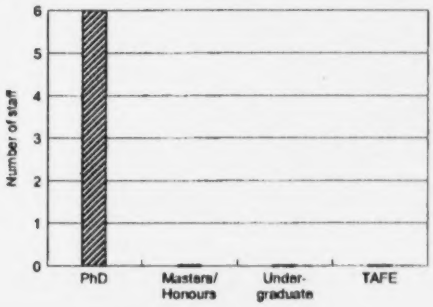
Sureka Goringe was previously a senior project manager at James Hardie. These teams were successful in the development both of new products and new manufacturing processes for these products; the products each had 10-year economic value assessment projections of over $100m. In this role, she was responsible for project management, personnel management, intellectual property, economic modelling and product and process implementation.

In addition to this role, she was also technology support manager for James Hardie. The technology support team provided technology support for all functions of the James Hardie business, including operations and marketing. Prior to the roles described above, she worked as a development scientist for James Hardie. She has a PhD in materials science from the University of Technology, Sydney, and an MA(Hons) from the University of Cambridge, where she was a winner of the Cambridge Commonwealth Trust scholarship.

She has recently been awarded the Women's Scholarship at the Australian Graduate School of Management.

The remaining staff are applied to specific projects and all have PhD qualifications.

Figure 16: Staff qualifications profile for Redfern Polymer Optics for 2001



Current recruitment

Current recruitment for Redfern Polymer Optics is as follows:

Chief engineer

The essential qualification for this role is a degree in science or engineering.

Production engineers (2)

The essential qualification for this role is a degree in science or engineering; however, this role could be undertaken by a VET graduate (in an area such as fitting and machining) who has industry experience.

Device characterisation engineer

The essential qualification for this role is a degree in science or engineering.

Staff projections 2002–2004

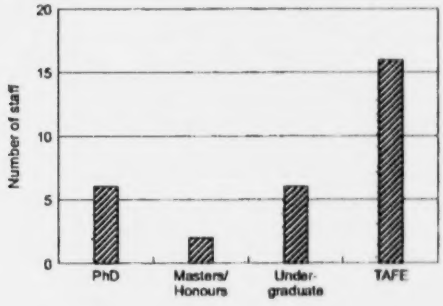
Recruitment is not expected to expand in 2002 beyond the likelihood of using contractors for specific pieces of work. The five-year plan projects at a minimum a single product company, with specific manufacturing plant, which houses 30 staff. At best, the company will have several product lines, each with their own manufacturing operations. There may be somewhere of up to 10–20 products and therefore upwards of 600 employees.

Several assumptions are made, however:

- ✧ venture capital investment will come from Australia
- ✧ the first product will be a success in development
- ✧ the prototype will be satisfactory and acceptable
- ✧ customers will be found and connections will be made
- ✧ the intellectual property will stay in Australia
- ✧ manufacturing will occur in Australia
- ✧ the company will not be sold outright.

The most conservative projections for 2004 are for upwards of 30 employees with the following qualifications profile:

Figure 17: Staff qualifications projections for Redfern Polymer Optics in 2002–2004



VET sector involvement

Current involvement

The company has not yet recruited staff. It is likely that the company will be located in the ACT and therefore the training requirements for VET may fall to the Canberra Institute of Technology in the first instance.

Forces impacting on training in Redfern Polymer Optics

Recruitment strategies will have the strongest impact on training as the chief executive officer is adamant that recruitment forms his central core role. The recruitment strategy in the early phase is to focus on hiring staff who do not need any training/retraining. In this context, the company 'will not hire university post-graduates who have no teambuilding, teamwork or interpersonal skills' (chief executive officer, Redfern Polymer Optics). It is anticipated that this will form the main strategy in relation to skills for at least the first two years of operation.

The main criteria for employment once the candidate has the essential technical capability are:

- fit with the remaining team
- cultural fit with the existing advanced manufacturing industry.

The main emphasis in the early stages of the company will be keeping the ratio of industry persons to university persons balanced, with the vast majority coming from industry. The chief executive officer of Redfern Polymer Optics says: 'I'd rather hold up the growth of the company than hire the wrong person'.

Training needs

The company did not identify any training needs in the short term as it is still in the early stages of development. In the medium term it will need training in:

- environmental health and safety
- operations
- team leadership
- management training.

The company would be unlikely to release staff for training outside the organisation but would bring in a contractor/registered training organisation to do that training. It would be required to be delivered as a customised training package. The company did not hold the view that an outside organisation would have the required knowledge to conduct the training. All learning would need to be based on an action learning model and be able to be applied in the workplace (and thus integrated with the employees' work in a strategic way).

By 2004, it will require manufacturing operators and TAFE/VET graduates in photonics and manufacturing management.

Impediments to training

The company identifies time sensitivities as the critical impediment to training investment (in particular, a lack of time). This was considered to be even more sensitive for a start-up company than for a mature organisation. Cash costs of training were not seen to be an issue if the company was delivering a profit. Training was viewed as an investment in staff morale and productivity or process improvement.

Redfern Interlink—company 8

Redfern Interlink is the latest addition to the Redfern Photonics Group. Redfern Interlink is in the early stages of being established and plans to install, commission and operate Gigabit Photonic Networks together with demonstrating photonic systems and equipment.

The main focus of the company has been the development of business plans for the roll-out of a national high bandwidth optical fibre network, with the first stage linking educational and research

institutions, hospitals and government agencies in NSW. In the second stage the company plans to deliver true broadband solutions to corporate clients. These services include affordable high-definition video conferencing and ultra-large data transmission.

Corporate structure

The company has been partnered with the NSW Government, and via this relationship will access key infrastructure (public sector optical fibre and rights of way), as well as key public sector customers (government and community agencies). The network will provide a valuable reference point for Australian photonic products, as well as a vehicle for showcasing innovative Australian broadband internet services and software.

The following table outlines the main developments in the company since its inception:

July 1999	Interlink conceived
December 2000	Applies for BITS funding

The company is dormant until such time as funding is received.

Current staff and management

Currently Redfern Interlink has no permanent staff, one consultant and expects to commence recruitment in 2002 after achieving an investment boost and new commercial partners.

Recruitment forecasts

Recruitment into Redfern Interlink Pty Ltd is not expected to commence until venture capital funding or government support is achieved. Without a business plan, it is impossible to forecast staff numbers.

VET sector involvement

Without a business plan it is impossible to determine training needs.

Photonics Redcentre—company 9

The Photonics Redcentre was established in July 1997, with funding from the Department of Industry, Science and Resources under the Technology Diffusion Program. Its aim was to accelerate the development of products from concept to customer and beyond, through provision of networked technology access with effective commercial solutions.

At 30 June 2000, the Photonics Redcentre had 41 associates comprising 36 small to medium enterprises, four universities and TAFE NSW. A number of successful networks have been established to address development and marketing issues associated with the commercialisation of new products.

The early success of the Redcentre's approach to technology networking was significant. In fact, 13 companies, 55 jobs and A$25 million in export earnings were delivered. As a result of its incubator experience, Redcentre was a successful applicant as part of the Information City Pty Ltd consortium for the Commonwealth Government's BITS funding for start-ups in the information technology and training sector. Information City won $8 million of funding, which was matched by $8 million of venture capital. Redcentre will run the communications/photonics incubator for Information City. It commenced operation in July 2000.

Redcentre's new initiative with CEOS Pty Ltd is REDlab, a leading-edge test laboratory for the development of telecommunications, opto-electronics and high-tech electronics products. It provides access to the latest test instruments to small to medium enterprises, universities and co-operative research centres and large companies. The five foundation members of REDlab comprise Redcentre, CEOS, Nokia Australia, Pacific Broadband Networks and the Australian Photonics Co-operative Research Centre.

In July 2000 Redcentre established itself as the trading name for Redstart Pty Ltd with the executive director, Terry Polkinghorn, supported by two part-time administration staff and several key photonics industry specialist advisers. Australian Photonics Co-operative Research Centre holds a minority interest in the company.

Redcentre is now in the business of:

- networking technology solutions for small to medium enterprises
- incubating start-up information technology and training businesses through Information City Victoria
- investing seed capital in opportunities through a pooled development fund.

The Redcentre expects to develop approximately five photonics-based companies in the next five years. Currently two are in incubation status and have three staff.

Corporate structure

Redcentre has a network structure. Its core operation is in Melbourne and is essentially a small organisation with administrative support for itself and its emerging companies.

Current staff and management

Executive director

Terry Polkinghorn is a graduate of electronics engineering with post-graduate qualifications in manufacturing technology and a Masters Degree in Enterprise and Innovation from Swinburne University of Technology. He has won several awards in business planning and published papers on networking with small to medium enterprises. Currently he serves as a director in four small to medium enterprises and has planned and started several companies.

He has served on industry associations and was a member of the National Innovation Summit 2000—Industry Innovation Working Group. He has a MEntInn, GradDipMfg, DipEE and a CPEng.

Investment advisor and director

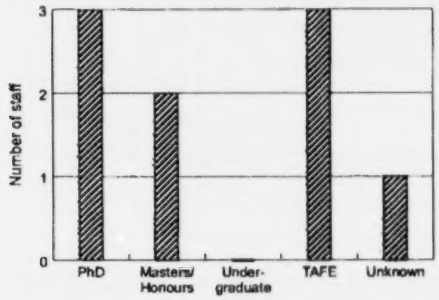
Hugh Gurner is a director of Redstart. He is also a founding director of Citadel Pooled Development Ltd, an ASX-listed investment company which was established with the financial support of five major financial institutions: JP Morgan, National Australia Asset Management, Mercantile Mutual, ASBC Asset Management and AMP.

Remaining network (staff) contributors are in:

- business development and export
- business specialist photonics—business strategy adviser
- international business and strategy
- photonics business and technology mentor to Redcentre associates.

Remaining staff are in administration roles.

Figure 18: Staff qualifications profile for Redcentre



Current recruitment

Redcentre is not currently recruiting any new staff.

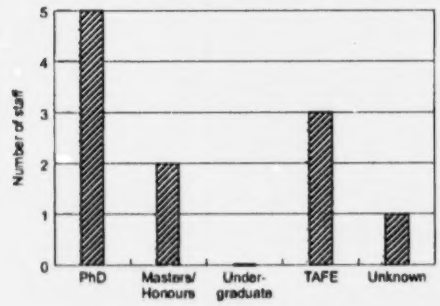
Staff projections and qualifications profile for 2002

Redcentre expects to expand its operations as the incubator companies develop. Two companies are already in the incubator cycle. These staffing requirements are described as follows:

Company	Staff 2000	Staff at 12/2001	Staff at 12/2004
A	2	25	50
B	1	3	30

At this stage, it is difficult to determine the qualifications profile of these companies for either 2001 or 2004. Redcentre itself expects to attract another two technical business staff. It is anticipated that these people will require PhDs.

Figure 19: Staff qualifications profile for Redcentre in 2002



VET sector involvement

Current involvement

There is no current involvement between the Redcentre and the VET sector beyond its strategic alliance with TAFE NSW previously described.

Forces impacting on training in Redcentre

The ***utilisation of a network structure*** was given as the greatest single impact in determining training need. Training was not seen as necessary at this stage.

Training needs

The Redcentre did not identify any current training needs. Its longer-term skill needs will be solved through utilisation of a network structure where appropriate skill is brought in on a project-by-project basis.

Impediments to training

A lack of need was given as the only impediment for training in this company.

Kadence Photonics—company 10

Kadence was a new organisation in 2000. Its mission is to achieve high-volume automation subcomponent manufacture for the photonics industry with superior process technologies.

The Kadence team will develop a manufacturing capability, sell and service generic sub-components and licences, and create a test and measurement business organisation to facilitate market entry.

The following table outlines the main developments in the company since its inception:

May 2000	Chief executive officer/chief technical officer join forces
May 2000	Business plan developed
September 2000	Business founder investment
October 2000	Company established
December 2000	COMET grant received, Australian Photonics P/L loan received
Anticipated: May 2001	Venture capital in place $3.5 million

Corporate structure

Kadence expects to follow a business franchise model, where the manufacturing facilities and the intellectual property it generates can be outsourced to regional areas. Each regional area manufacturing capability will be aligned with an educational institution (most likely a TAFE college) to ensure that regional economic development is supported.

Kadence currently consists of the management team of two and one contracted staff. It plans to hire a chief operating officer as well as create a small, flexible technical team with industry experience. Staff numbers are not expected to exceed 24 in the Sydney branch.

Current staff and management

Chief executive officer

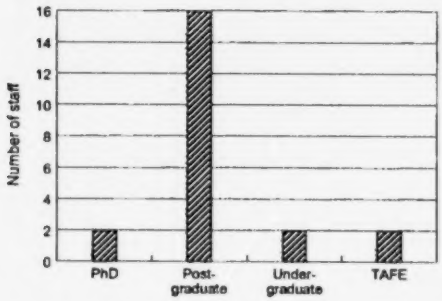
Mrs Maggie Alexander is the acting chief executive officer, business and marketing communications manager. She is a business consultant and lecturer with over 20 years experience in technology-based organisations. She is a former senior executive with Digital Equipment Corporation. She holds a BA (Communications), MScSoc and a Diploma in Teaching.

Chief technical officer

Dr Peter Hill provides the technical direction for product development and experience in the design and manufacture of automated manufacturing solutions. His key scientific and technical achievements include: ultraviolet laser design and construction, tuneable optical fibre gratings, and the founding of automation in the co-operative research centre (later transferred to INDX and to Photonic Technology). He holds a BSc(Hons) (First Class) and a PhD in Molecular Physics. He is currently studying for his Masters degree in Engineering Practice, Business and Technology.

Staff projections and qualifications profile for 2002

Figure 20: Staff qualifications projections for Kadence in 2002



VET sector involvement

Current involvement

Kadence's involvement with the VET sector to date has centred around its alliance with Lidcombe College of TAFE. Undertaking joint research and development with TAFE, it has already been able to demonstrate outcomes in fibre handling, precision fibre coating stripping, fibre clamps, remote fibre location mapping and fibre laying.

It expects to recruit TAFE staff into regional manufacturing centres and anticipates that TAFE colleges will align with manufacturing operations in regional areas.

Peter Hill, the chief technical officer, prefers to use TAFE colleges and staff in the development of new knowledge and processes because:

- TAFE staff have the capacity to contribute ideas from the moment they are involved in a project and have little difficulty in articulating their ideas.
- TAFE has a better capacity (than universities) for innovation because of its operational style. (In his view, the hierarchical style of universities in relation to intellectual property can inhibit this process.).
- TAFE staff use innovation as a teaching tool in their student-based practical projects.
- TAFE staff's practical industry experience can elicit better outcomes in the development process.
- TAFE has a better capacity to recognise and utilise the intellectual capital of the surrounding community.
- In the minds of TAFE staff, it's not a large conceptual distance to practical implementation from the concept of an innovation. (Peter Hill, chief technical officer)

Forces impacting on training

Success of the early product in the marketplace and its manufacturing operations will determine the training needs of the company. Until the company reaches a stage where it produces the franchise, the need for training cannot be determined.

Training needs

The company does not have any training needs at this stage and is not in a position to articulate its needs for the future. It anticipates that this will be possible once venture capital funding is in place.

Impediments to training

The company did not comment on impediments to training as it was too new to determine if any existed.

Virtual Photonics Incorporated—company 11

Virtual Photonics was established in 1996 to manufacture, and market globally, photonic computer aided design software design tools, based on research from the Australian Photonics Co-operative Research Centre at the University of Melbourne.

In January 1999, Virtual Photonics Pty Ltd and Europe-based BNed GmbH merged to form the new global corporation, Virtual Photonics Incorporated, with centres in Melbourne, Berlin and San Francisco. The merger with BNed brought complementary expertise to the new company, and greatly expanded the market reach for products being developed in the Virtual Photonics Incorporated development centre in Melbourne.

Virtual Photonics Incorporated now makes design and planning tools for access providers, network operators, system integrators and manufacturers of WDM transmission systems and optical components. Development groups are located in Munich (broadband access), Holmdel, New Jersey (intellectual property/optical networking), Australia (Optical Systems) and Minsk (software production). Technical expertise and a formidable customer base are establishing Virtual Photonics Incorporated tools as the language for innovation and exchange across the bandwidth value chain. The company's software is being selected by the world's leading telecommunications companies.

The merger means that Virtual Photonics Incorporated will package and market its software tools using Australian Photonics Co-operative Research Centre expertise at design centres across the Asian region.

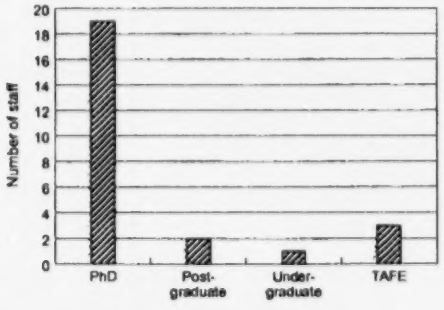
The formation of Virtual Photonics Incorporated strengthens and expands efforts to serve a rapidly growing market. Australian Photonics Pty Ltd maintains a minority stake in the company. Virtual Photonic's Melbourne centre is expanding at the rate of 400%pa and is finding that demand for staff outstrips supply. 'The principals of the founding entities play leading roles, while the development team is growing from 40 to 60 experts this year' (Iverson, chief executive officer, Virtual Photonics Incorporated 1999).

Corporate structure

The Melbourne office is one of a set of offices of Virtual Photonics Incorporated internationally and thus the corporate structure is not applicable to this study.

Current staff and management

Figure 21: Staff qualifications profile for Virtual Photonics Inc.

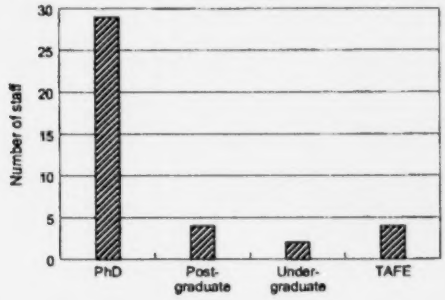


Current recruitment

The company was not recruiting in 2001 but expected to increase its development staff by the end of 2002.

Staff projections and qualifications profile for 2002

Figure 22: Staff qualifications projections for Virtual Photonics Inc.



VET sector involvement

Current involvement

Virtual Photonics Incorporated currently has no involvement with the VET sector.

Forces impacting on training

Lack of supply of skilled labour was a factor in training. The company was concerned that it would have difficulty in its next phase of recruitment but, as can be seen above, it will be recruiting staff who hold PhDs. The general manager of Virtual Photonics Incorporated said: 'We sell expertise packaged as software'.

This company is a specialist in the design of photonics systems and, as such, has to be ahead of its competitors. Virtual Photonics Incorporated has its own training division as it needs to train the company's software users.

The main force impacting on the company to train is the introduction of new technologies and the adoption of new software products.

The company was most concerned by the loss of leading Australian academics to US-based companies and research institutions. This meant there were fewer academics in Australia to supervise postgraduate researchers. They were also concerned by the lack of undergraduate courses in photonics and low student numbers in Australian universities in this area.

The company did not see a problem recruiting qualified engineers from overseas.

Training needs

The following training needs were identified by the company:

- ✧ project management
- ✧ business skills
- ✧ customer service and sales
- ✧ specialist software courses (proprietary)

- writing skills—technical writing
- communication.

Impediments to training

The company did not identify any impediments to training.

The story of !ndx, now JDS Uniphase—company 12

In February 1996, the Australian Photonics Co-operative Research Centre launched its first start-up company, Indx Pty Ltd at the Optical Fibre Conference in San Jose. The company was formed to manufacture and market the centre's range of application-specific optical fibre products and fibre Bragg grating filters based on technology developed and patented by the centre.

In the first two years after its formation its managing director, Dr Simon Poole (formerly a key researcher in the centre), had developed the company from a small three-person team with an annual turnover of approximately A$1 million, to an enterprise valued at approximately A$10 million and a staff of 15, most of whom transferred from the centre as staff or students. This is a remarkable achievement, given the centre's seed investment of only $800 000 to underpin the company until an equity partner could be found.

In November 1997 Indx, with a staff of ten, was acquired from its co-operative research centre parent by the United States company Uniphase Corporation. Uniphase had intended to make a 49% investment in Indx, with an option to acquire the remaining shares at a later late. However, as discussions evolved, both parties determined that the second-phase acquisition should be brought forward.

JDS Uniphase is headquartered in Nepean, Ontario and San Jose, California and is a high technology company that designs, develops, manufactures and distributes a comprehensive range of products for the fiberoptic communications market. These products are deployed by system manufacturers worldwide to develop advanced optical networks for the telecommunications and United States cable television industries. JDS Uniphase Corporation is traded on the Nasdaq. The company bought a number of photonics-based companies in 1999 and 2000, as well as purchasing its major competitors SDL and E-Tek, and some smaller start-up ventures. JDS Uniphase is now the premier photonics component manufacturer and supplier globally.

Indx, which is now known as JDS Uniphase Fibre Components, is based in Sydney to manufacture and market high performance gratings for a full range of wavelength division multiplexed applications, primarily for the telecommunications market. Indx was the first company to introduce temperature-insensitive fibre Bragg gratings in 1995 and has continued to build on this capability.

JDS Uniphase Fibre Components is now a participant in the Australian Photonics Co-operative Research Centre and its researchers are working on collaborative projects with centre researchers to develop new products for export to a rapidly expanding market for wavelength division multiplexed products.

The Sydney headquarters of JDS Uniphase is located at Ryde. On 6 April 2001 a new building was launched to house new manufacturing capability. The total capital expenditure of the company in Sydney has been approximately A$40 million and once the building is completed that figure will grow to A$60 million.

According to the Prime Minister[1], the Sydney operation of JDS Uniphase accounted for 10% of Australia's telecommunication exports. Analysts also predicted sales of US$3.3 billion for the fiscal year ending 30 June 2001.

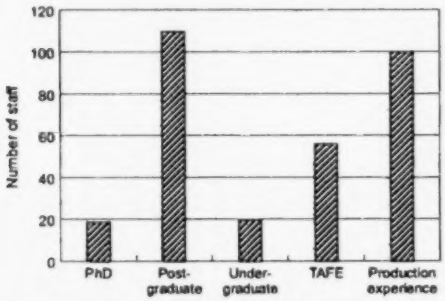
Corporate structure

Employees number over 300, with 50 people in research and development. JDS Uniphase expects to continue to expand employee numbers to 350 by June 2001.

Due to the downturn in the telecommunications industry, the company announced on 25 April 2001 that it will cut 5000 jobs, which is about one-fifth of its current workforce. Its Australian and Asian operations are not expected to be affected.

Current staff and management

Figure 23: Staff qualifications profile for JDS Uniphase



The qualifications profile of JDS Uniphase is distinguished from the other organisations in a number of ways.

- ✧ It has a high level of experienced production persons. JDS Uniphase noted that it recruits a large number of staff that are overseas qualified. Thus the people in this area are not entry-level workers in the traditional sense of the term.

  > Many of our staff have degrees and diplomas from overseas institutions that are not recognised in Australia. Most of our staff have some previous skill or qualification. Many have previous inhouse training or company-specific certificates in production or manufacturing.

- ✧ JDS Uniphase does not recruit school leavers or staff without qualifications or experience.

  > The work is too complicated. Staff need strong underpinning knowledge of photonics or electronics manufacturing.

- ✧ It has a large number of staff with postgraduate qualifications. The JDS Uniphase organisation in Sydney has also retained quite a large research and development function. JDS Uniphase was first to market in Australia in the photonics industry. Many of the staff have share options and are essentially 'locked in'.

- ✧ For the past three years, JDS Uniphase has also employed every graduate from the Bachelor of Technology (opto-electronics) at Macquarie University.

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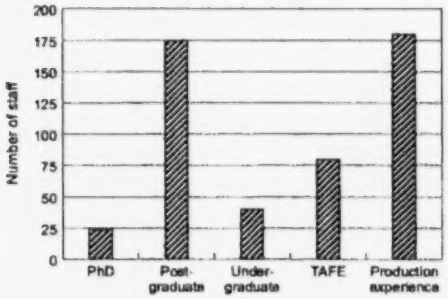
[1] Prime Minister Howard, speech on opening the JDSU building, 2001.

Current recruitment

JDS Uniphase recruitment is focussed on obtaining employees in the areas of manufacturing production and photonics research and development.

Projected staff qualifications profile 2001–2002

Figure 24: Staff qualifications projections for JDS Uniphase in 2002



It is interesting to note that the number of postgraduate qualified staff is expected to nearly double in the following 12 months as is the number of experienced production positions.

VET sector involvement

Current involvement

Lidcombe College has delivered fee-for-service courses to JDS Uniphase. The 'Photonics Industry Overview' is targetted at new employees. This was a customised and shortened course delivered for new recruits to the company.

Recently Lidcombe College has begun to develop both a photonics course for mechanical engineers who are developing manufacturing equipment, and one for employees who need an advanced course in gratings because their experience lies elsewhere in related technology.

Forces impacting on training

JDS Uniphase identified employee development as the main force impacting on training.

> We seek to have highly developed employees in the company as it motivates employees and having a development plan helps us to retain them. (Human resources manager)

Training needs

Company training needs fall into two main areas:

- management
- technical.

Training was also required to support new workers to obtain the underpinning contextual knowledge about photonics as a discipline area.

Impediments to training

JDS Uniphase identified a number of impediments to training. These included a lack of availability of short courses and induction training, a lack of specific course topics relevant to the company, and time constraints caused by production deadlines.

Jiangsu Fasten Photonics Co LTD—company 13

No representatives from Jiangsu Fasten Photonics were interviewed.

Jiangsu Fasten Photonics Co Ltd was registered on 26th November 1999 as a joint-venture company between the Australian-based Redfern Photonics Pty Ltd group and the Jiangsu Fasten Group, China. Redfern Waterloo Pty Ltd is the management company for the relationship with Jiangsu Fasten Photonics. It has no full-time staff.

Its major products are optical fibre preform, optical fibre and optical components. It is anticipated that 60% of production will be for the Chinese domestic market and 40% for the overseas market. The first phase of funding achieved an investment capital of US$29 million (70% invested by Jiangsu Fasten Group and 30% by Redfern Photonics). The total investment capital forecasted until 2004 will be US$78 million.

Jiangsu Fasten Photonics' factory project has seen an investment of US$54 million.

Construction commenced on 28 November 1999 and is now complete. It is expected that by March 2001 the factory will be in full operation. At this point the annual production forecasted would be 3.5 million metres of optical fibre, an annual output value of US$2.7 billion and a pre-tax profit US$10.67 million. The large-scale venture will feed the growing demand in the Chinese market, using a new manufacturing approach that will give it a competitive advantage over imports. The market in China is estimated to exceed 10 million kilometres by 2002, and analysts conservatively estimate that the market will continue to grow at between 10–20%.

Current staff and management

The management team and board comprises people from the parent company in China as well as representatives of the co-operative research centre. The Fasten opportunity was introduced by Dr Yuxing Zhao, a graduate of the centre, who had been involved in its research and development program for the past eight years. The venture will create long-term linkages between Australia and China at many levels: in research, education and commercial spheres. The story of the development of the partnership is an interesting one.

Dr Zhao, like many Chinese students, came to Australia in late 1988 to undertake a PhD degree in photonics. At the same time the University of Sydney, with support from OTC (now part of Telstra), established the Optical Fibre Technology Centre. Dr Zhao was its first employee. He was granted permanent residence through the employer sponsorship program.

Dr Zhao was awarded his PhD degree from the University of Sydney and the co-operative research centre's postgraduate education program approximately two years ago. During this time he also visited his home town and met with his former high school teacher, now a senior local official. When he explained what he was doing in Australia, the official became very interested as negotiations between a major Chinese company and another major transnational to establish an optical fibre manufacturing plant in China had recently broken down. Dr Zhao returned to Australia where principals in the centre's start-ups showed interest in the opportunity to establish a joint venture in China. Visits were exchanged and the joint venture was formalised late in 1999. Dr Zhao has transferred to Jiangsu Fasten Photonics, taking up a senior position within the company. Principals of the centre's start-up company, Redfern Photonics, are members of the board of the joint venture.

This story demonstrates the value to Australia of investing in the education and training of students from China and other Asia/Pacific countries. The connections they make in Australia and their loyalty to Australian educational institutions can translate into lasting relationships and commercial opportunities. The venture will create long-term linkages between Australia and China at many

levels, in research, education and commercial spheres. Joint ventures are an important approach to accessing global markets.

Staff projections and qualifications profile

Staff projections and a qualifications profile for this company are not relevant to this study as the production of fibre will be conducted offshore and beyond the management of the agreement. The company does not house staff in Australia.

Ambri Ltd—company 14

Ambri Ltd listed on the Australian Stock Exchange on 23 August 2001. The data collection and interview process occurred prior to this event. The company owns a unique, patented and proprietary biosensor technology. This technology will be marketed as a series of single-use disposable strips, targetted at specific applications and a dedicated measuring instrument, with applications in many areas. Ambri Ltd will demonstrate the utility of its technology by initially adapting it to specific medical diagnostics and drug discovery products. Subsequently, Ambri Ltd will license other uses for incorporation of the technology into further products and markets. The biosensor can directly quantify targetted substances at the commercially required levels of concentration. It will deliver the functionality and performance required of an analytical device regardless of application. Ambri Ltd products will be packaged for use in the field, in laboratories, in emergency departments, industrial plants and drug discovery facilities.

The Australian Membrane and Biotechnology Research Institute (AMBRI) undertook the initial research on the ion channel biosensor and gave its name to Ambri Ltd. From 1992–1999 AMBRI was the major partner in an Australian Government-funded co-operative research centre, the Centre for Molecular Engineering and Technology, which further developed and demonstrated the capability of the technology. Ambri Ltd was formed in 1995 and, as the research matured, it became progressively more involved in preparing the technology for commercialisation. With the completion of the centre's grant period in April 1999 the centre staff transferred to Ambri Ltd, which now conducts all of the biosensor research and development. Ambri Ltd was a wholly owned subsidiary of Pacific Dunlop Ltd.

During the 1990s Pacific Dunlop Ltd was a diversified Australian manufacturing conglomerate selling into the consumer market in the fields of electrical goods, automotive parts, textiles, and medical products. In 2002 Pacific Dunlop was the world's second largest producer of condoms and surgical gloves through their Ansell division. The annual revenue to 30 June 1999 was US$2.4 billion. Pacific Dunlop's involvement with the Ambri technology began in 1989 when it acquired Nucleus Ltd, which was a founding member of Ambri.

Ambri Ltd is the exclusive licensee of the Ambri Technology and is committed to bringing biosensor products to market as soon as possible. This licence is worldwide, and covers all fields of use.

The Ambri technology is protected worldwide by a large suite of patents, and the company intends to build on and protect this substantial intellectual property base. The company monitors new patent and patent applications worldwide.

Corporate structure

Ambri utilises a traditional management style. The company is sufficiently well-defined to have work organised into specific areas with multidisciplined teams.

Current staff and management

Managing director/chief executive officer

Joseph Shaw BSc(Hons), MSc, PhD manages and directs Ambri Ltd, achieving its goals through the effective use of business assets and human resources. An American, Dr Shaw has had a career in the development of products in the pharmaceutical and diagnostics areas. As well as having been a member of Johnson & Johnson's executive team in Canada, Dr Shaw has founded two diagnostics companies, selling one and taking the other public. He has extensive experience in the development and commercialisation of unique technologies. He has broad international experience, having worked in Canada, Italy and the United States as a senior executive in medical corporations.

Senior vice-president and chief scientist

Bruce Cornell has a BSc (Physics) from Monash and received a PhD from Monash in 1974. Dr Cornell's main responsibility is to advise the managing director on technical and scientific issues. Dr Cornell was the principal architect in establishing the Ambri consortium. He was the principal investigator on two Australian Government grants awarded to develop the Ambri biosensor concept, and subsequently became the director of the Co-operative Research Centre for Molecular Engineering.

Chief operating officer/chief financial officer

Fiona Dring, BA DipEd, Macquarie University 1986, accounting, University of Technology, Sydney 1990. She is responsible for managing the overall operations of Ambri Ltd. Ms Dring joined the head office of the Nucleus Ltd Group in 1992, which at that time owned a number of high-tech. medical-related businesses. She was appointed the group financial controller in 1994. In late 1995 she was appointed chief financial officer of Ambri Ltd and in 2000 she was appointed chief operating officer. Mrs Dring was formerly with Ernst & Young for five years. She is a member of the Institute of Chartered Accountants in Australia, the Securities Institute of Australia and the Chartered Institute of Company Secretaries in Australia.

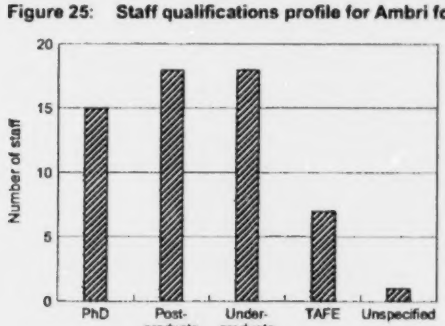
The remaining management team consists of:

- vice-president, operations
- vice-president, engineering and electronics
- vice-president, research and development.

Ambri Ltd currently employs 59 full-time staff. Fifteen staff have PhD degrees, and most have graduate scientific qualifications. This level of staffing is expected to suffice for the product development phase.

Current staff qualifications profile

Figure 25: Staff qualifications profile for Ambri for 2001



As can be seen from the graph, Ambri Ltd is heavily geared toward higher-level qualifications, although this now includes considerable experience in the commercial sector.

Current recruitment

Ambri Ltd is not recruiting any staff at this time. Usual recruitment methods would include as a preference word of mouth and networking, and the use of a recruitment agency.

Qualifications profile 2001

No changes to the staffing profile are expected in the short term. However, it is anticipated that once manufacturing occurs, additional staff will be recruited into:

- manufacturing staff, automation, robotics and macaronics (seven staff). Of these four will be VET/TAFE qualified
- sales, domestic and international (20 staff, with a combination of clerical and administrative roles). The qualifications of these staff will vary and industry experience will be a considerable factor in recruitment selection.

Facilities

Ambri Ltd occupies 2000 square metres of well-equipped laboratories and office space at Chatswood, NSW. The laboratories include a major synthetic organic chemistry capability, which permits both specialist pilot synthesis and large-scale production of fine chemicals. The biochemical laboratories are used for the expression, purification and modification of bio-molecules. An extensive range of clean room and surface physics equipment is suited to the development and production of high purity thin metallic films and microelectrode arrays.

VET sector involvement

Current involvement

Pacific Dunlop is a registered training organisation and frontline management initiative training is currently being conducted inhouse. This will be accredited by Pacific Dunlop. Ambri Ltd is seeking to develop relationships with an appropriate TAFE partner for training, and future research and development.

Forces impacting on training

The lack of existing skills of university researchers in team management, financial management and communication has been identified as a significant problem by this company. A clear cultural divide exists between a company and a research group and, in the case of Ambri Ltd, resulted in more than half the scientific staff leaving the company over the first two years of operation. The company initially found it difficult to identify staff with the necessary commercial team culture. These issues have now been resolved. These commercial skills are said to be more common in the United States.

The need to work in teams is critical to the success of the company. An employee must be able to see where their job fits into the main scheme of the company and how any changes made by the employee affect other workers and the product. The inability of managers to identify a need for training was also said to impact on training.

The need for inhouse training caused by new policies and procedures such as: standard operating procedures, quality assurance systems and new production procedures has been identified as a major driver for training.

Training needs

Training for all staff, postgraduate, undergraduate and TAFE-qualified is required in:

- induction
- good laboratory practice
- quality control
- blood-handling procedures
- occupational health and safety procedures
- manufacturing processes
- train-the-trainer for management staff who have written the new procedures.

Impediments to training

The expenditure in external training is low. Cash cost is the major factor here. The inability of managers to identify a need for training has been seen as an impediment to the implementation of training and skill development in the company.

Main findings and conclusions—relevance to, and implications for VET

Introduction

The data show clearly a strong demand and role for VET in the establishment and development of small global high-technology companies. Training provided by the VET system is implicated in the following areas:

- technical skills in photonics and biomedical/diagnostic areas
- electrical and mechanical engineering
- production and manufacturing
- project, financial and team-based management
- recruitment and human resources
- quality assurance
- sales and marketing
- occupational, environmental health and safety

The need and demand for VET qualifications is very strong.

The following section describes the findings of the research in the same format as each of the case studies.

Corporate structure

Many of the companies reflected the culture of US-based operations. The use of the terms vice-president and the roles of chief technical officers and general counsel show the influence of American investment in those organisations. Decisions to utilise the management titles and organisational structures reflect the perceived need of these Australian companies to be accepted in the American market. There is a perception that in order for successful relationships to develop, Australian-based companies must adopt a cultural style that Americans can relate to and which meets their expectations. Many companies recruit staff that have worked for overseas multinationals such as Nortel or Corning, and were quite specific about their need to have people on board with diverse backgrounds who were familiar with the global nature of the business and the United States 'way of doing business'.

A number of companies in the study are no longer wholly owned in Australia. The financial ownership of the companies did not appear to affect training except in so far as the companies which had received investment moved quickly to their next stage of development, recruited the required qualified staff and thus created a demand for 'just in time' training as well as a demand for professional qualifications.

Interestingly, the mix of senior executives is strongly Australian, with most being drawn from leading managers in the telecommunications industry and a significant number who also had start-up experience. The pool of talent in this area was seen as quite deep. This is particularly

encouraging because there is a perceived need, often espoused in the media, to recruit globally and employ people from overseas. It is interesting to note that, to date, all of the chief technical officer positions were filled by researchers previously working in the co-operative research centre. In addition, many of the chief executive officer positions were filled by previous chief executive officers of Australian companies that were partners of the centre, such as Fibernet Pty Ltd.

In this industry, a 'brain gain' also appears to have occurred with many overseas-born and educated scientists working in this area. This is largely due to the high quality of research opportunities.

The corporate or organisational structures of the start-up companies are diverse and reflect the development stage of the organisation. The structures range from traditional hierarchical models to networked models, project-based management and potential franchise operations.

Generally speaking the companies were at various stages of development and were aiming for quite different kinds of companies and operations as their growth outcome. Some will aim to be large global multinationals and some will aim to be wholly owned Australian companies with offshore operations. All have export orientations and all have skill needs that will be demonstrated onshore.

The phase of development and the management and knowledge requirements change fundamentally as the company moves through the product life cycle. This can be described as follows:

Phase of development	Management style characteristics
Research and development	Loose management style. Ability to work individually and without supervision
Prototype development	Small management teams. Team-specific based projects for development with contractors on specialised pieces of work
Single product or niche product	Moderate-sized management team. Traditional company management structure. Team-based projects with strong interdependence. Ability to work to deadlines and deal with rapid change in processes.
Mass production global export	Moderate size management team. Traditional company management structure. Clear but complex management matrix with intra-company divisions for administration, product development, manufacturing and production

The requirement for additional management skills was described by nearly all the companies interviewed, including Ambri Ltd. The needs of companies were described in terms of management of:

- teams
- projects
- problems
- finances
- communication
- resources
- health and safety.

Importantly for VET, companies did not specify these skills only for staff in senior management roles, but for staff at all levels.

There is no doubt that the VET system could respond to these needs, but would most likely do so on a fee-for-service basis. Competitive government funding (CTP in NSW) may also be available to support these firms but is variable in its supply.

Current staffing and management

The total number of staff across all companies in early 2001 was 505. This was expected to grow to 1060 between the end of 2001 and mid-2002. Interviews and data could be obtained for the Redfern group and for some, but not all, other groups. The figures for staff numbers and VET participation are as follows:

Staff numbers for photonics by company

Company name	Number of staff at 1/4/01	VET qualifications now	Projected staff as at December 2002	VET qualifications projected to 2002
Australian Photonics	9	0	10	1
Redfern Photonics	16	4	16	4
Redfern Fibres/Nufern	15	5	20	6
Redfern Optical Components	15	1	119	Up to 95
Redfern Integrated Optics	28	2	130	Up to 56
Redfern Broadband Networks	73	7	162 (Dec 2001 only)	30 (Dec 2001 only)
Redfern Polymer Optics	6	0	30	16
Redfern Interlink	1	0	1	Unknown
Redcentre	9	3	11	3
Kadence	3	0	22	2
Virtual Photonics Incorporated	25	3	40	4
JDS Uniphase	305	56	499	> 80
Total number	**505**	**81**	**1060**	**Up to 297**

The qualifications profile of all companies is as follows:

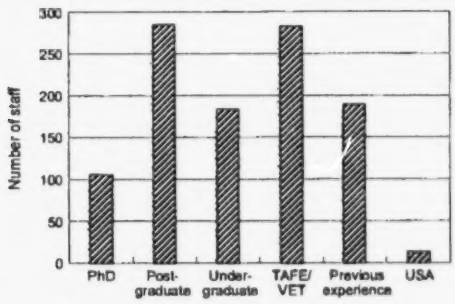
Staff numbers for photonics by qualification

Qualification	April 2001	Projected 2001–2	Per cent increase	Per cent of total workforce
PhD	79	106	34.18	10
Postgraduate	149	285	91.28	27
Undergraduate	86	184*	113.95	17
TAFE/VET	81	283*	249.38	27
Experience—no Australian qualifications	109	189	73.39	18
Unspecified	1	0		0
USA**	0	13		1
Total	**505**	**1060**	**109.9**	

* Where the company specified either category of qualification, the figures were given to the higher award. So some jobs may in fact be filled by persons with a lower level of qualification.

** US jobs of Australian-based company for Redfern Broadband Networks. This study has not counted US jobs for Nufern as it is now headquartered in the US, nor has it shown any data for Jiangsu Photonics headquartered in China.

Figure 26: Staff qualifications projections for all companies for 2002



The table shows that the TAFE/VET qualified jobs created by 2002 will number at least 283 and the number of university-qualified positions will be 575. Of these, 419 are postgraduate qualifications. The proportion of VET jobs now in the cluster is 16% but will rise to a minimum of 27% and is, in fact, likely to be higher by 2002. Interestingly, the profile of Ambri Ltd is similarly proportioned across qualifications.

Companies noted that the qualification demands were not necessarily for new workers. In fact, many noted that they required both university and VET graduates with experience. The preference from companies was not to recruit fresh from the universities or TAFE. Where this had occurred, in most cases, students were undergoing classes to obtain recognition via a qualification of their existing skills. Even JDS Uniphase, who has recruited all graduates from the Bachelor of Technology Optoelectronics, Macquarie University, advanced this view.

The findings in this study can be contrasted with a recent (2000) unpublished survey of 12 generic Australian photonics firms conducted by Tekhne Pty Ltd for the Australian Photonics Co-operative Research Centre. In their study, a total of 2750 jobs would be created by the 12 firms sampled by 2010, of which 1200 would require VET/TAFE qualifications. This would represent 43.6% of the total demand at that time.

Qualifications forecast for photonics

Qualification	Forecast 2001	Forecast 2010	% increase	2010 % of total
PhDs	65	140	115	5.1
Postgraduates	70	300	329	10.9
Undergraduates	300	920	207	33.45
TAFE	190 (29.4% of total)	1200	532	43.6
Non-graduates	20	190		6.9
Total	**645**	**2750**	**326**	

Data supplied by Tekhne Pty Ltd for the Australian Photonics Co-operative Research Centre

There are a few notable points in the studies. In the first instance, a comparison shows that the number of VET-qualified workers in the firms sampled by Tekhne is higher than in the centre's firms sampled by this study. This could be explained by the fact that companies in this study are in much earlier stages of development than the ones in the Tekhne sample, as several of their companies were large multinationals and therefore quite mature. This current sample comprised only one reasonably mature company—JDS Uniphase.

Secondly, this study only asked about 2002 projections. The figures obtained may reflect the fact that these companies will still be undertaking research and development activities at that time and that by 2010 the market will be more fully established, with less demand for high level postgraduate

skills. (DWDM fibre may well be in homes and fully optical networks will be the norm.) This appears to be quite likely and is discussed more fully in the next section under forces affecting demand.

Thirdly, both studies identified the need for experienced workers with perhaps no recognised formal qualifications. However, in this study the need was identified by just one company and with the understanding that it was *most* likely that these workers would have overseas qualifications. The number of workers in both samples is relatively similar (18.8% in our sample for 2001–2 and 14% of the total required by 2010 in the Tekhne sample). None of the other companies identified this need and in some cases were adamant that these workers would not be required.

The Tekhne study concluded by forecasting that the entire Australian photonics industry would, by 2010, create approximately 24 700 new jobs. The number of VET-qualified jobs they predicted was 10 560. On the basis of proportional representation above, this current study would predict rather lower numbers and on the basis of current expectations would forecast a minimum of 6669 jobs requiring VET qualifications by 2010. If we include the proportional representation for entry-level workers and assume there may be an uptake of traineeships (once traineeships were created), then the Tekhne forecast of 50.5% would nearly hold (45% in our study). This would give 11 115 jobs in relation to VET qualifications, thus confirming that these companies would require assistance from the VET system in a significant manner.

Given the fact that we do not know the size or earnings of the Australian companies in the industry, it would be wise to exercise caution in this study in relation to forecasting actual future demand. Another caution would be in relation to the disruptive nature of the industry. Early industry development is cyclic, it is filled with uncertainty and very high highs and very low lows. To a large extent the industry growth is assured in Australia and one must keep the faith when one hits the troughs and exercise restraint when one hits the highs. The chief executive officer of Australian Photonics Ltd, Mark Sceats notes that if one was to recalculate the growth of the companies over the last few years accounting for the heady growth in the late 1990s and the downturn in 2000–2001, employment would still be tracking at 20% each year. Thus the hypothesis of rapid industry growth has been substantiated by the growth of the individual companies in this study and the industry globally. It is reasonable to argue that significant numbers of workers will be required and that demand for VET qualifications will be strong regardless of where the industry is in the cycle.

VET sector involvement

It is important, firstly, to note a few items of major significance that affect the ability of these organisations to interact with the VET system. As at December 2001:

- There was no current training package for photonics, nor were there any registered apprenticeships or traineeships.
- Attempts by TAFE, the co-operative research centre and the representative organisations to get appropriate competencies in photonics technology and manufacturing into the telecommunications training package over the last three years have failed, as there has been no review of the package.
- There is no supplementary national funding outside the funding for training packages to support training development or the development of national qualifications in new industries such as photonics.
- State funding in NSW has been applied to the development of a course in photonics fundamentals which has, to date, been delivered to over 150 people by Lidcombe College of TAFE. This course is accredited with the Vocational Education and Training Advisory Board in NSW and nationally recognised, but stands outside the national training package framework. It is, however, a nationally recognised qualification.

- Many participants in this study had both VET and university postgraduate qualifications. These persons were not counted as VET graduates in this study as they had pre-existing postgraduate qualifications and were usually employed with that qualification.
- As at December 2001, training for the photonics industry was only occurring in NSW, although the Canberra Institute of Technology and the Royal Melbourne Institute of Technology were developing their awareness of photonics by attending conferences and symposia and visiting NSW TAFE facilities. This will enable training delivery in those states. However, the effort in this area is meagre at this stage.
- To date, only one company interviewed has actively tried to recruit VET-level-qualified photonics technicians from the labour market and thus there is a lack of knowledge about availability. Ironically, it is this company which has the strongest university graduate-seeking culture.

VET involvement possibilities

There are a number of ways these companies could interact with the VET system that would be beneficial to both organisations. A table describing these activities and the VET involvement of these companies follows:

Type of involvement	Involvement
VET registered training organisation delivery of training on the job	Not as yet—under consideration
Combined registered training organisation workplace on/off-the-job delivery	Not as yet—under consideration
Employing apprentices*	None available in photonics
Employing trainees*	None available in photonics
Lobby industry training advisory boards and BVET, ANTA	No—on their behalf by the centre
Assistance in the delivery of courses	Yes
Facility tours for registered training organisations students and staff	Yes
Guest lectures at TAFE	Yes
Provide information to TAFE/colleges etc.	Yes
Host student visits	Yes
Recruit TAFE graduates	Yes
Teacher professional development	Yes
TAFE involvement in applied research and development	Yes
Become a registered training organisation	No
Donate plant and equipment to colleges	No but possible in the future

* There is no Vocational Training Order for this area in NSW

By all accounts, the interviews indicated that these organisations are engaged as fully as they can be with the VET system within the limitations of existing conditions. Further involvement would be assisted by the inclusion of photonics competencies in training packages and government subsidies for short course delivery to new workers in photonics.

As can be seen from the previous table, the number of VET graduates in these companies is currently very low, but is expected to show an increase in the short term. Not one company anticipates the need for apprentices or trainees in the short, medium or longer term and most see a TAFE diploma as a minimum standard of qualification for entry to employment, with one company strongly indicating it requires a minimum standard of university graduate.

No organisations identified entry-level workers as having a place in the company, and many companies were quick to point out that the staff without Australian-recognised qualifications in general had degree or VET-level qualifications from overseas institutions. The same company noted that many of these workers had company-specific certificates, perhaps in circuit board manufacture or similar other qualifications which may not be recognised under the national system.

Only one company said that they would recruit a long-term unemployed person, but this action was undertaken as the company's contribution to the public good. Such action was dependant upon whether the company could find a person who could be appropriately trained and had reasonable personal communication skills. By all accounts these companies are looking for highly skilled workers.

All companies were happy to assist in this study, as they all could see the need for VET/TAFE-trained technicians for their own growth and future industry growth. They are also pleased to assist and take TAFE and school students on work placements and work experience and have done so on a number of occasions.

The fact that the companies understand that they need to assist in the longer-term development of the industry is attributable to the transfer of university researchers into these organisations and thus the university culture of investing in school outreach activities. These outreach activities are perceived to be the main way that university faculties drive demand for a particular discipline. All interviewees completely understood the importance of participating in school and TAFE placements and outreach activities, and were able to cite instances where their companies had participated in such ventures.

Current involvement in training activities is sporadic and is fundamentally dependant upon the stage of development of the company. Companies in the research and development phase or at very early stages of development are not inclined to view training as such a high priority as those about to commence manufacturing operations. This is discussed in the next section.

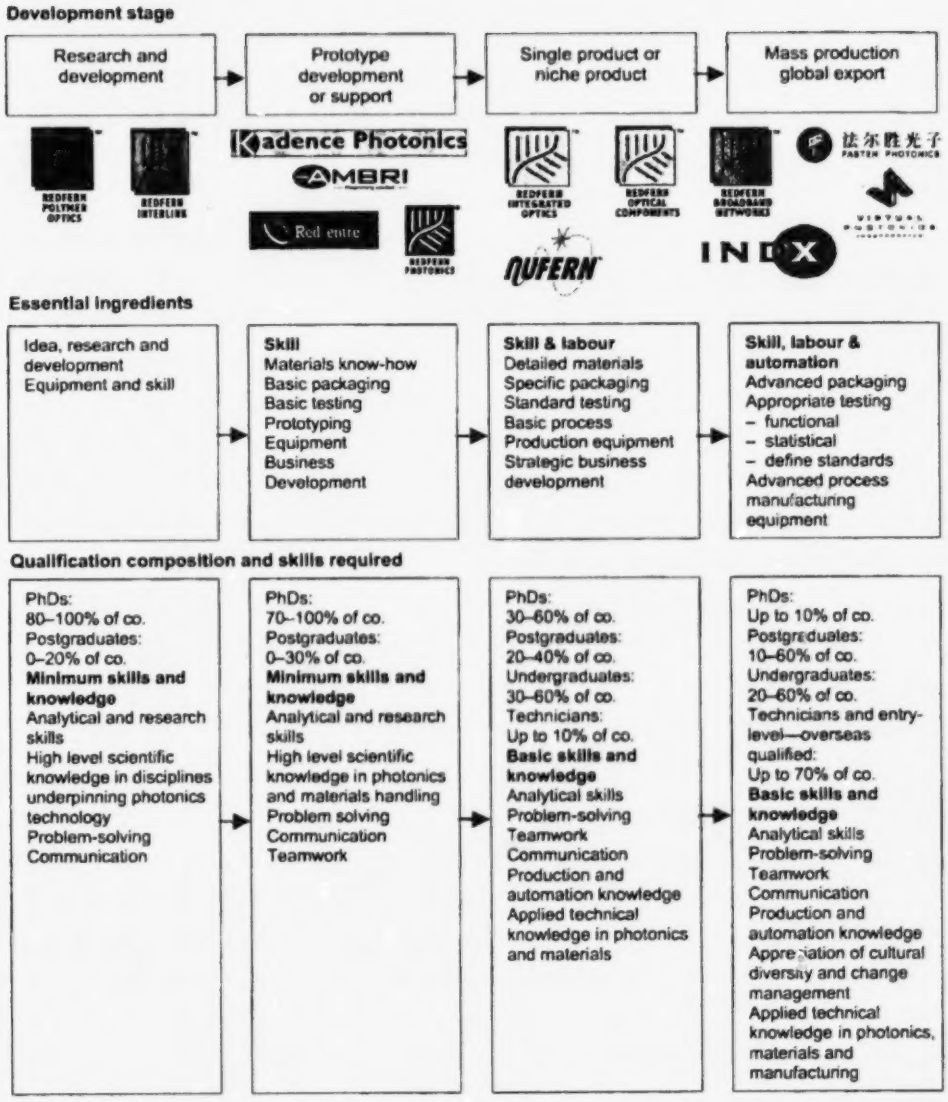
Ambri's involvement with the VET system is tighter, in that its parent company is a registered training organisation and delivering frontline management training. This is a situation created by critical mass and a level of organisational maturity that the photonics cluster has not reached as yet.

Most importantly, the degree of awareness of the VET system predetermined the way the companies described their needs. Those who understood the system would describe their needs being fulfilled by registered training organisations and the courses accredited under the training package system and those who did not described their perceptions of the TAFE system, its courses and its colleges. Ignorance of VET or not is a significant factor in how a company engages with it.

Forces affecting demand and need for training

Corporate structure and phase of development

It is clear that the qualifications profile and skill requirements of each company change as it develops. The following table illustrates this in terms of the companies profiled as well as a function of their stage of development. A feature of the empirical relationship between industry growth rates and the demand for skills is that it changes as industries mature. This could be understood in terms of a shift in the dominant activity of photonics components firms from research and development to manufacturing at a point in their growth path.



High rates of growth were also a factor affecting training demand. The USA Opto-electronic Industry Development Authority dimensioned[4] the photonics industry as having a market of US$21 billion in 1996 and in February 1997 it was reported in *Optics and Photonics News*[5] that the US market research firm, ElectroniCast, in its Dense Wavelength Division Multiplex Products Global Market Forecast predicts the DWDM component of the market alone at US$12.1 billion by 2005, a huge increase over the US$101 million market in 1995.

[4] Opto-electronic Industry Development Authority report cited in Tekhne 2000, SLI application
[5] *Optics and Photonics News* 1998

The most recent forecast made by RKH Incorporated has revised the value of the photonics industry to 24 billion by 2004.

American investment has been a major influence affecting demand for training. Without investment, a company cannot grow, recruit staff, purchase plant and equipment or implement manufacturing operations. Such investment brings some cultural expectations which can be challenging for management and could be addressed by training in cultural diversity. Sale down (full or partial) of the company could also cause the manufacturing operations to shift overseas. In the case of Nufern, over 200 manufacturing jobs will be located in the US. It is possible that these jobs may have been located in Australia if sufficient Australian venture capital could have been found.

Paradoxically, the recent downturn in the growth estimates of the industry globally also meant that anticipated training demand would be lower than previously expected. The companies in this study have not revised their recruitment forecasts downward. However, it is apparent that as a consequence of the global economic downturn, these companies may slow their rates of growth. In Australia, this will mean that the urgency of the training need is lessened. Note, however, that while all multinationals are laying off staff worldwide, one multinational company (JDS Uniphase) has not cut staff in Australia at all. Interestingly, it appears that for all companies it was intended to take the intellectual property to full scale commercialisation—rather than to exit the investment by trade sale to a manufacturer.

Recruitment and building up to full-scale manufacturing and automation was another critical determinant for training. As these companies recruit new staff, they need to ensure that their core processes are in place and that staff can undertake their roles successfully. It was assumed that once staff were recruited, the customised courses available to companies currently would fill the need for any additional training required. Many of the staff from non-photonics backgrounds would need to be aware of the theoretical constructs underpinning photonics technologies.

It is interesting to note that a number of companies indicated that changes to existing processes were also a factor indicating a training need. This appeared to be a little contradictory to the notion that procedures were not in place. The need to deal effectively with change on the shop floor is consistent with high rates of growth, as is the introduction of new products and the increasing automation of manufacturing or production processes.

Orientation and reskilling of new employees with advanced post-trade qualifications was identified. The need to 'cross train' workers was seen to be a growth area for training in at least two companies.

Finally, across all companies, including Ambri, the difficulties in managing teams faced by university researchers who have become new management employees was also a major factor influencing the companies' decision to train.

Training needs

Attitudes to skill development training and training investment

While demand for training may be high, the need is often poorly articulated and full of misconceptions about the training system, which is not well understood. Generally, the attitude of chief executive officers and human resources managers to training and its providers was fairly positive, with all respondents keen to assist in the development of such training because it was seen to advance the industry in Australia.

This was supported by the main findings of the Tekhne Pty Ltd survey:

- The majority of the respondents reported a commitment to training of their staff. Companies actively encouraged skills enhancement, allowed part-time study and supported such study, except in the case of small and relatively new firms.

- Many companies provided workplace training and were interested in flexible modes of teaching and learning for staff, including instructors visiting the workplace. Companies expressed the importance of quality in training and the relevance of training to competitive performance.
- Most companies were concerned that the availability of skills might be insufficient for growth plans. Companies were strongly in favour of government initiatives to address this issue. Except for small and relatively new companies, they were also prepared to invest in their own training needs.
- Some companies reported that policies must ensure that skilled people would have incentives to remain in Australia, or to return to Australia after training overseas.
- Some companies reported current activities to promote interest in photonics and other information technology and training careers. Most companies were agreeable to supporting outreach initiatives through visits to company premises and involvement of staff in creating interest among students.

In addition to the comments above companies in general were interested and focussed in their support of education and training. There was a tendency to be overwhelmed by requests for information from a variety of sources, including government. However, once recruitment activities were completed, time could be devoted to supporting students and trainers from educational institutions. A disturbing feature of industry responses in the Tekhne study was that many of the firms expressed concern about the possible lack of skilled workers to meet company growth plans.

If the Australian photonics industry is to grow, there is now an urgent need to provide some assurance to companies that programs are in place to generate adequate numbers of skilled workers to support their investment in growth. In our study, specific training requirements in relation to technical staff were not identified as a major need, as it was assumed that the required personnel would be found through TAFE or in the marketplace without too much difficulty. It was not anticipated that there would be a great deal of direct recruitment from colleges, as previous experience in production was required. There was a reasonable level of awareness by the companies of courses and classes available through NSW TAFE and other colleges throughout Australia in manufacturing and production, automation and electronics. However, there was little consideration of the rate of supply of graduates to the workforce, that is, it is unlikely, given the current level of training occurrence in TAFE, that their expectations will be met.

Demand for qualifications and skills

The types of VET qualifications being sought were across a number of areas and not just specific to the discipline of photonics. These were:

- photonics technicians
- software development, information technology and networking
- electrical and mechanical engineering
- manufacturing production (perhaps even ex-fitters and turners)
- sales and marketing management
- office administration and human resources
- accounting and finance
- workplace training and assessment.

This confirms that the role of VET is much broader than the provision of technical competence, particularly in the context of organisational development. It also shows that the VET system contributes directly to the ability of Australian companies to innovate.

In our discussions with chief executive officers, human resource managers and, in some cases, the chief technical officers we found different attitudes to training and a number of common themes. Many opinions were similar to those made by their more mature industry counterparts, while others were particularly unique. In relation to training, the following themes emerged:

Unique to high technology start-up firms

- The need to take PhD and Masters 'virtuosos' (who were often found to be unemployable, because of their single-person project focus) and infuse team work, leadership and communication skills.
- The reliance on foreign investment and the links and ties to established markets in photonics, which creates a possibility that manufacturing jobs will be located offshore and training demand will suffer as a consequence.
- A perceived greater difficulty for smaller companies to find the time or resources to release staff for training activities that larger or more fully developed companies could afford to do.
- The high level of underpinning knowledge and skill required even at the manufacturing technician level.
- The fact that training is not seen to be an enabler of business success in this (research and development and niche manufacture) phase of development of the company.

Similar

- The reliance on recruitment as a form of intellectual capital-building.
- The need for inhouse company-specific training in relation to procedures or transfer of company intellectual capital.
- The need for contextual learning on the job.
- The importance of generic skills and key competencies.
- The need for frontline management training.
- The need for EHS/OHS training.
- The multicultural nature of the workplace.

Impediments to training

The impediments to training in these companies are fairly traditional and many can be found in the literature on investment in training. Reasons given for not investing in training can be explained as:

- factors within the company
- factors external to the company.

Within-company factors were:

- state of development of the company. (If manufacturing or development processes were not in place, a person's skill level could not be evaluated so nor could their training requirement.)
- perceived time constraints within production-line deadlines
- high-level knowledge workers who could self-manage and learn on the job
- knowledge transferred outside the organisation
- perceived value to the company at its point in development
- cultural bias toward traditional VET providers.

External company factors were:

- lack of available courses
- lack of available trainers/instructors
- cash cost of training and lack of government support
- lack of a cohesive industry to support co-operation amongst companies on training issues
- structural weaknesses in the education system in identifying and anticipating needs
- a lack of knowledge transfer between the higher education and VET systems.

Impediments identified contained enough significance to cause a change in the level of productivity or success of firms in the longer term. Attitudes to training could be more positive and companies certainly could be better informed about VET. Government support for companies in early start-up phases would assist them in their growth and subsequent profitability and also with the export competitiveness of the company.

Comments and observations

This project aimed to investigate the needs of companies in the photonics industry that are emerging and developing. By their very nature they may not have solid intellectual capital beyond their core processes and technology. They are dependant upon recruiting people who have a broad range of skills and knowledge. In fact, it could be said that they 'do not know what they do not know'. The findings of this research could be cast in that frame of reference.

The companies do not know what the VET system can offer and what the capabilities of VET graduates are. As a consequence, there is a tendency to assume in many areas the system will not be able to meet their needs.

One of the other main reasons why co-operative research centre researchers/company managers could not articulate their needs clearly or precisely was that many were too early in the research, development, commercialisation cycle. At a more fundamental level, a company with a product specification and a chief executive officer/entrepreneur but without investment is also usually without a realisable business or commercialisation plan. More simply put, it is a business proposition. As was noted in the introduction, a company without a business plan is one that has not determined its development, manufacturing or production systems and therefore does not have a human resource plan. Thus it does not know what type of workers it needs, the qualifications it wants, or the essential skills its culture requires. It is only through a maturing process that these companies can understand their VET needs.

The current involvement of these companies with the VET sector is actually quite broad. However, it is in indirect ways and little is known by these companies about the VET system, its funding sources, funding which may be available to them and the mechanisms in place for them to articulate their needs (i.e. industry training advisory boards).

Only one company had staff with an understanding of the VET system and what it could offer and could articulate the needs of the company in a manner that could be understood in the context of VET. As a consequence this company was undertaking additional responsibilities to act on behalf of other companies in the group. This would be unique to this study and may not be shared if one looked across the biotechnology sector for example.

In the interviews, the researchers observed that the level of knowledge about the Australian National Training Authority, the national training framework, national recognition of qualifications and the difference between TAFE training and VET was poor across the group or non-existent in most of the companies. This lead to great difficulty when trying to ascertain numbers for the qualification demand as some managers/chief executive officers assumed they would want a minimum bachelor

qualification for entry to employment in the company, when the position might have been better filled by a VET diploma graduate with some telecommunications industry experience. There are only 81 VET graduates of 505 staff in these companies (and many of the VET graduates were in administrative roles not technical ones). Because of this, it is difficult for company managers to know what to expect from a VET technical graduate, and to trust a decision to employ such a person, particularly since the rest of the company has come from a university culture and the existing staff seem to be culturally biased against VET.

It was significant to note an implicit assumption by the companies and their human resources managers, that the VET system was prepared and able to supply the graduates that they need and in the numbers they would require in the future—an assumption that, on current VET investment, could not be met.

There was also recognition that failure to provide skilled workers could mean that decisions would be made to locate operations where skilled labour could be found—in the United States and Canada in particular. At least one of the start-up companies (now only partially Australian owned) will be locating its main manufacturing facility in Connecticut and that company will have over 200 workers in the plant's start-up phase.

Issues for VET

Training availability and delivery by the VET system to date

Disruptive technologies, such as photonics, start with small student demand even when their economic impact is considerable. If one waits for high student demand to appear before developing the educational resources, one creates the likelihood, caused by the time lag between development and delivery, that the demand will be met some other way. This could involve moving the technology development and manufacturing offshore to a country that already has the education resources, for example. Moreover, it creates a market constraint in labour supply which forces the companies to change business strategy, and where a decision to commercialise fully in Australia may be taken, a licence agreement to an offshore agent occurs.

The VET system has been 'on notice' about photonics for some time. NSW TAFE provided information about the need for training in the emerging industry to the state telecommunications industry training advisory board in 1998. It also developed a photonics industry overview course at that time, which is fee-for-service and delivered to companies and individuals. A revised training package was due in 1999. Since this has not occurred, the industry is waiting for a national qualification in photonics to support its development. NSW has accredited its short course even though the training package revision was always 'just around the corner'.

Plans are underway to have a Photonics Technicians Advanced Diploma accredited in NSW for student enrolment in first semester 2002. The design of the advanced diploma will include flexible entry and exit points, and learners may exit with a lower level of qualification. In the case of the need for short and sharp training, learners may leave with a statement of attainment in a specific skill area or enterprise or company training need.

The first advanced diploma graduates from this course will not be available to the industry until late 2003 or early 2004. By this time the industry may have needed several thousand new employees with some photonics knowledge.

Assuming the course is accredited nationally, enrolments can occur in NSW in two colleges, and possibly in the ACT at the Canberra Institute of Technology. Modules can then be delivered on the job by any registered training organisation with expertise. Currently there are no photonics-based registered training organisations operating in the industry.

This will leave new firms with a few interesting choices in relation to skill development:

- make greater political representation and 'call' a skills crisis
- invest heavily in 'unaffordable' inhouse training
- forge stronger alliances with VET providers
- locate technical or manufacturing operations overseas where education systems have responded more swiftly

VET must examine its product development system to address these needs.

Training is not the only way that the VET system can assist the growth and export potential of these companies. At least one firm identified the specific expertise in TAFE colleges to be advantageous in product development. Applied research and development is not something for which the VET system has a reputation, but is occurring in many colleges. This is a specific but unharnessed VET capability which could be developed more fully to assist in the innovation capacity of the nation. It is an undiscovered country. The WA Department of Training strongly supports initiatives in this area by funding such initiatives to the value of $1 million per year. The VET system has much to offer in this area and this would be one of the best ways to foster collaboration between the higher education sector and VET for the transfer of new knowledge.

Opportunities and issues for the VET system

The descriptions of these companies have major implications for VET. Their skill needs indicate that a higher level of knowledge, innovation and communication is required by all workers, even those from the VET system.

The consequences for major sectors of the VET system are as follows.

VET planners including ANTA, state training authorities and state departments:

- require skills in identifying emerging industry trends and determining rapid changes in technologies. There is a greater need for flexibility and responsiveness at a national level
- need to be better able to anticipate the need for training in early stage start-up companies and therefore be more vigilant in identifying these companies and the clusters they form
- need to focus more widely on providing training at Australian Qualifications Framework levels 5 and 6 because entry-level workers are not required in the formative stages of high technology industries. Trainees and apprentices are also not expected to have a place in the industry.

VET providers need to:

- consider their investment in pre-emptive or just-in-time vocational education and training to meet the market need when it occurs, not after the need has been established, proven and possibly moved on
- provide trained workers who can articulate their needs, be aware of cultural differences, undertake problem-solving and participate in team work
- provide training to new firms that is industry relevant (i.e. up to date with the latest technology and business processes), customised, just in time and on the shop floor
- focus more strongly on providing training at AQF 5 and 6
- create stronger links with research organisations and participate in applied research and development projects
- establish partnership arrangements with industry as well as other educational institutions, to promote the timely development and delivery of training. This can assist in the sharing of human and physical resources.

Industry training advisory boards need to:

- be better able to anticipate the need for training and therefore be more vigilant in identifying new organisations and clusters of companies around new economic activity as they form
- focus more strongly on articulating the need for providing training at AQF 5 and 6
- support the development of training packages that incorporate the needs of new small to medium enterprises who may not be sufficiently well-represented so as to articulate their needs to the appropriate bodies
- have a mechanism for developing and incorporating competency standards from new and emerging industries in training packages in a timely and responsive manner.

The Australian National Training Authority needs to:

- develop funding mechanisms for training for emerging industries and companies
- develop mechanisms for the transfer of knowledge from the higher education sector to the VET sector and for the appropriate notification of successful commercialisation of Australian public sector research and development in order to provide assistance in a timely manner
- place a greater emphasis on collaboration rather than competition between training institutes and states in 'new or thin' training markets
- promote and support efforts of VET providers working with science and technology innovators where there is an undefined training market and expensive intellectual capital entry
- put in money for a project to push to create a specialist TAFE with this capacity to help start-up companies etc. ... act as advocates.

Recommendations for future research

There are a number of possible areas for future research that would be beneficial to the VET system. These are as follows:

- a broader study of the skill needs of emerging high technology firms, perhaps in areas such as biotechnology, nano-technology, advanced multimedia and visualisation, advanced manufacturing and renewable sustainable energy
- a study of the flow of knowledge created in the national innovation system and its current connections with the VET system
- a study of the diffusion models used by Australian research and development organisations
- a study on the effect of foreign investment into company development, cultures and training choices
- effectiveness of post-graduate university graduates in industrial placements—'Can a PhD researcher make the grade in industry?'
- a longitudinal study of the flow of intellectual property from the co-operative research centre to the start-up companies, their growth, and employment and training expenditure
- a deeper analysis and confirmation of the differentiation of training need across the company's/ firm's development and commercialisation cycle.

Appendix

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David O'Connor, general manager, Nufern International

Kyle McGinty, human resources manager, Redfern Broadband Networks Pty Ltd

Tod Campbell, human resources director, Redfern Integrated Optics

Ian Maxwell, chief executive officer, Redfern Polymer Optics

Maggie Alexander, general manager, Kadence Photonics

Peter Hill, chief technical officer, Kadence Photonics

Terry Polkinghorn, director, Redcentre

Arthur Lowry, director, Virtual Photonics

Melina Scardilli, human resources manager, JDS Uniphase

Michael Moulton, photonics teacher, Lidcombe College of TAFE

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